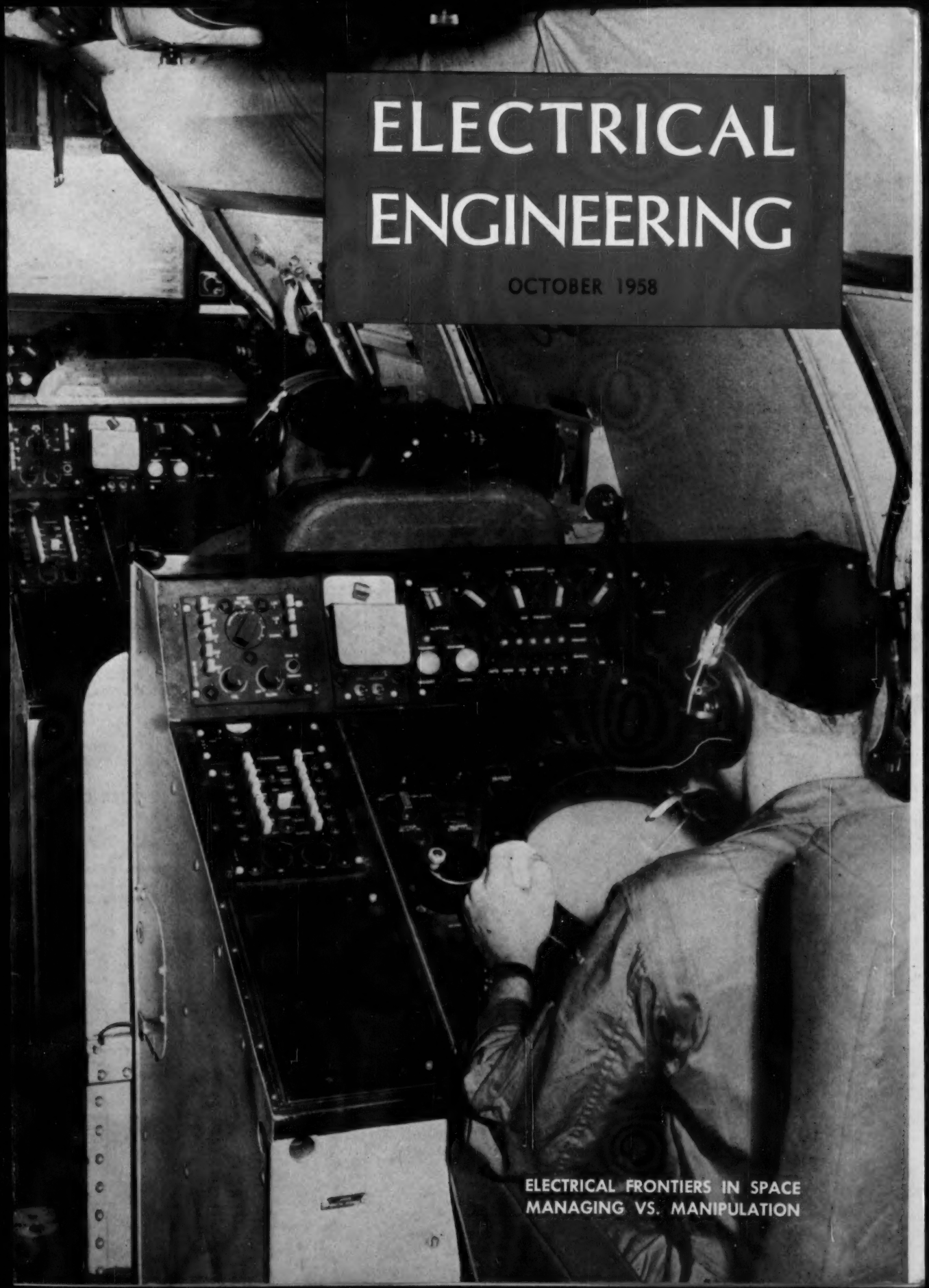
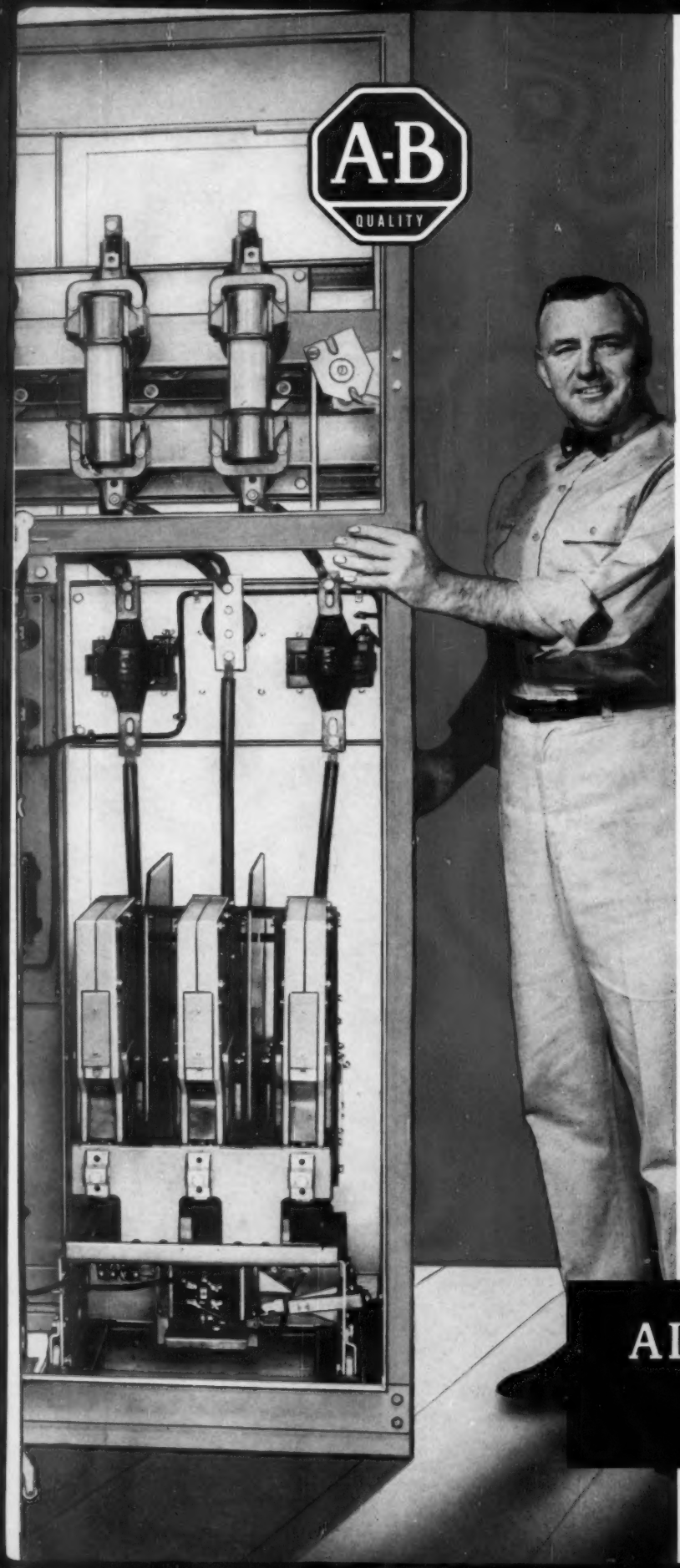


ELECTRICAL ENGINEERING

OCTOBER 1958

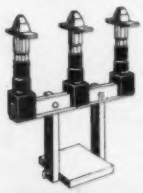
ELECTRICAL FRONTIERS IN SPACE
MANAGING VS. MANIPULATION



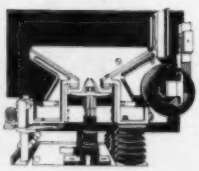
Tough high-voltage job?...Here's the answer!

Allen-Bradley High-Voltage Air Break Starters are ideal for frequent switching, reversing, plugging, or jogging.

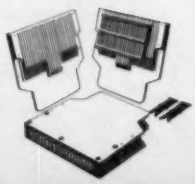
A tremendous operating life has been built into these high-voltage air break starters . . . resulting from the use of the simple solenoid contactor. It's the same design—having only ONE moving part—that provides millions of trouble free operations in Allen-Bradley's low-voltage controls. These starters are made in a complete line for all types of service. Send for Publication 6080, today.



ONLY ONE MOVING PART
With this simple solenoid design, all trouble causing pivots, pins, and flexible jumpers are eliminated. Straight up-and-down motion of contactor is virtually frictionless.



DOUBLE BREAK CONTACTS
Allen-Bradley silver alloy contacts never need maintenance . . . they remain in perfect operating condition until completely worn away. Vertical motion assures uniform contact pressures at all times.



FASTER ARC SUPPRESSION
The air break contactor employs a completely different blowout design and novel arc chute which assure rapid arc extinction. Chutes are molded from arc resistant material.

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MOTOR CONTROL
QUALITY

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ELECTRICAL ENGINEERING

OCTOBER 1958
Vol. 77, No. 10

Published monthly by American Institute of Electrical Engineers

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H. J. Birchal

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Rack-Panel-Chassis Connectors for RAPID DISCONNECT
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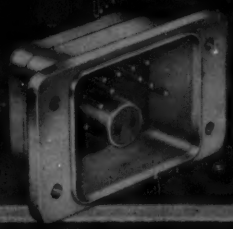

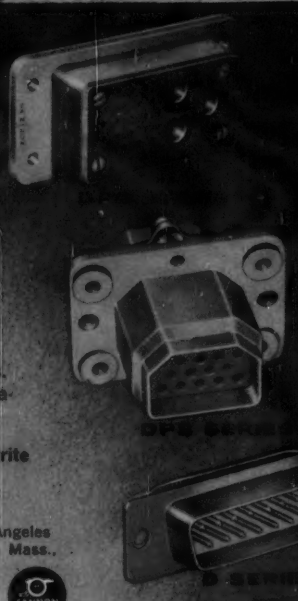

Cannon offers you more than 18 different basic designs in rack-panel-chassis connectors... designed with all the latest features to give you accurate alignment, easy mating, proper connection, and interfacial sealing where desired.

Select the connector you want in standard, miniature, or sub-miniature sizes... for standard circuitry or printed circuitry. Up to 156 contacts... and a great number of combinations of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. In single- or double-gang. Some with shells, some without... all ruggedly constructed to take the many "in" and "out" operations of rack, panel, chassis, and sub-assembly applications. Special moisture-proof types. Standby units featuring gold-plated contacts to withstand deterioration and corrosion.

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AWARENESS OF PROBLEM — INTEGRITY OF INTENT — DESIGN EFFORT — MANUFACTURING CONTROL

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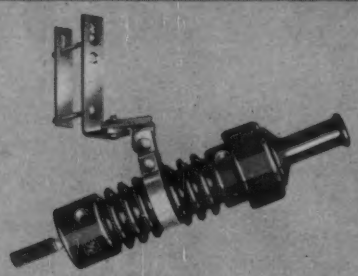
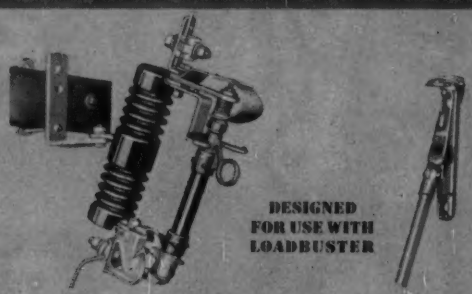
For every distribution system

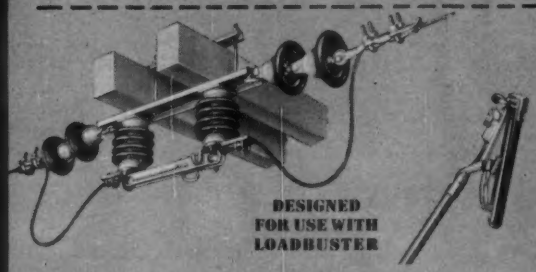
Four devices for low cost load switching at today's higher voltages and loads



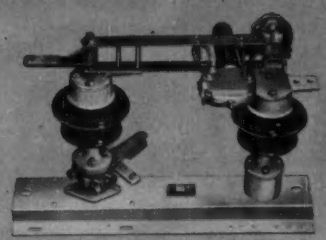
S&C POSITECT—enclosed cutout for full load switching, up to 200 amperes at 5 kv (or as a disconnect—unfused—to 300 amperes). Continuous rating: 50 and 100 amperes as cutout, 100 and 300 as disconnect. Note interrupter attachment at left.



S&C XS CUTOUT—an open cutout designed for use with LOADBUSTER®. Rated 100 amperes continuous as a cutout or 200 amperes continuous with disconnect blade. With LOADBUSTER it will switch full load, and associated charging and magnetizing currents.



S&C LOADBUSTER DISCONNECT—a distribution disconnect, with full published ratings and station-type performance. Rated 15 kv, 400 amperes continuous, 20,000 amperes momentary—95 kv or 110 kv BIL. With LOADBUSTER it can switch all loads, and associated charging and magnetizing currents.



S&C ALDUTI LOAD INTERRUPTER—SIDEBREAK STYLE—three-pole load switching device of long recognized capability. Used primarily for key sectionalizing points. Will interrupt all loads through 600 amperes. Made in 7.2 and 14.4 kv ratings.

S&C ELECTRIC COMPANY

Load switching is a real concern in modern distribution systems, with line voltages of up to 14 kv and load currents as high as 600 amperes. At these voltages and loads, it is impossible or extremely hazardous to open main or branch feeders with ordinary disconnects and cutouts.

Dropping all loads at the source, simply to open a single branch feeder, results in intolerable service interruptions. One alternative—switching with link-break cutouts—is an undependable makeshift. Another alternative—group operated disconnects—still doesn't bring full positive load switching, and is costly.

The S&C solution is a complete "stable" of distribution cutouts, disconnects, and load interrupters—all capable of providing full load switching, at prices to match distribution system economics.

The POSITECT Enclosed Cutout has its own load interrupter attachment. Two other devices—the XS Open Cutout and the Tool Operated Disconnect—are designed to take S&C's portable loadbreak tool, LOADBUSTER®. Finally, the S&C ALDUTI Load Interrupter has a built-in interrupting unit. This reliable interrupter switch has been the standard of the industry for many years.

For additional information on how to give your distribution system universal load switching capability, write to S&C.

S&C Electric Company
4427 Ravenswood Ave.,
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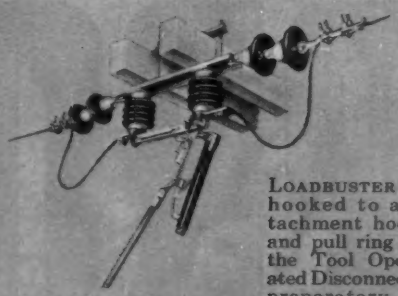
LOADBUSTER®...

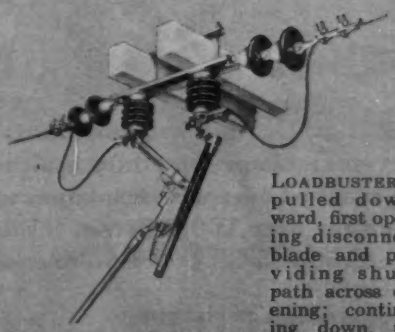
S&C's portable loadbreak tool

This new portable loadbreak tool is used at the end of a universal hook stick for opening disconnects and cutouts designed for use with it. On today's heavy loads, to 400 amperes, and up to 15 kv, this device gives arc-free load switching.

S&C manufactures two distribution devices mated to LOADBUSTER, the Tool Operated Disconnect and the XS Open Cutout. The sequence below illustrates LOADBUSTER opening the S&C Tool Operated Disconnect.



LOADBUSTER is hooked to attachment hook and pull ring of the Tool Operated Disconnect, preparatory to opening.



LOADBUSTER is pulled downward, first opening disconnect blade and providing shunt path across opening; continuing down, the circuit is then interrupted in LOADBUSTER, which latches open.

LOADBUSTER is freed from the attachment hook, then released from the pull ring of the disconnect with a twisting motion. Same procedure is followed for cutouts mated to LOADBUSTER.

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CERTI-SEAL, AMP's all new moisture proof window connector, prevents moisture breathing at altitude. Tin plated copper rings are crimped over wire insulation to seal out vapors and fluids. Made for over 100 different insulation diameters in military specifications, CERTI-SEAL exceeds all specifications for:

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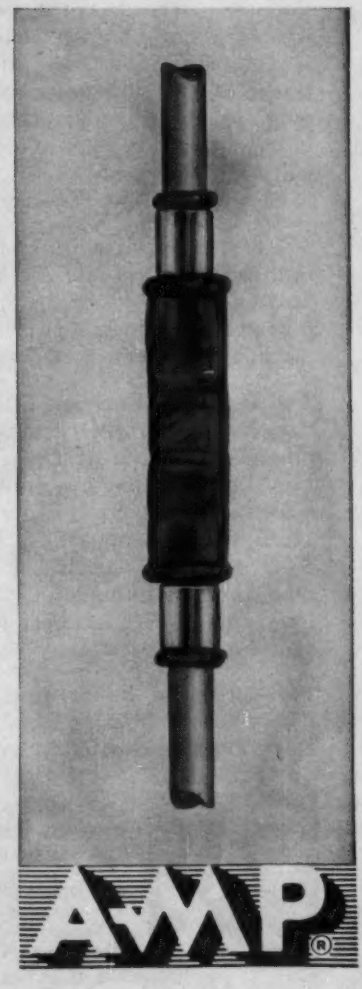

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NATIONAL TRADE-MARK brushes cured this balky power shovel...and helped 14 other mines!

M. B. INMAN

Constant brush trouble on a power shovel led this mining company to call in "National" Carbon Brush Man M. B. Inman. His recommendation paid off so promptly he was asked to check recurring exhaust fan trouble at another company-mine.

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The "National" Brush Data Survey idea soon spread to every company-mine in the state... then to all mines in the neighboring state—15 mines in all. This is typical of the service provided by your "National" Brush Man. Call him today, or write National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York.

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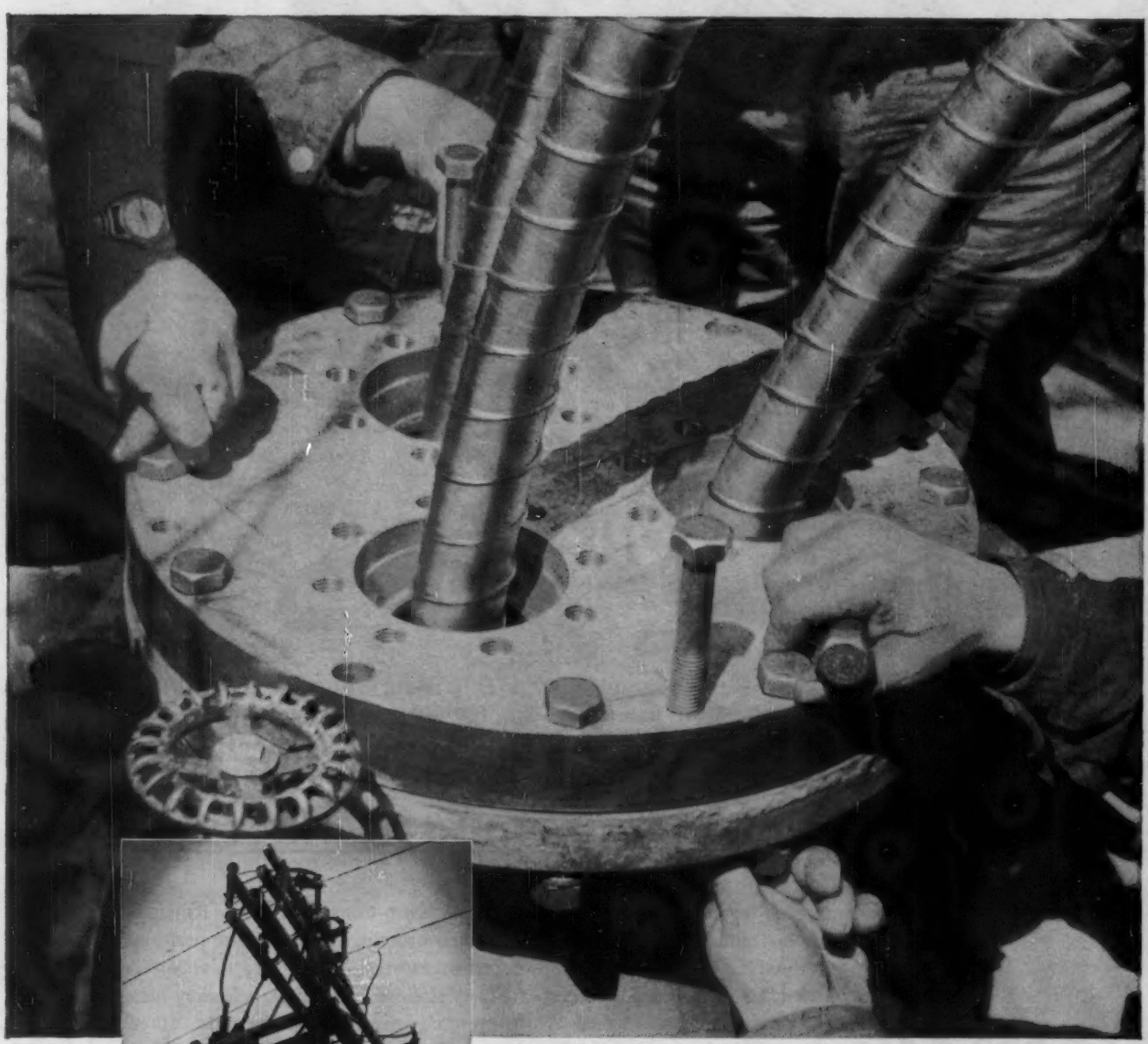

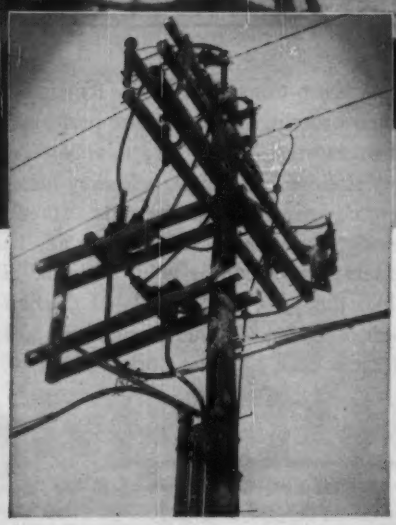

(above and top right) Installation of 1,500 MCM 69 kv High Pressure Oil Filled Cable and Terminal at Philadelphia Electric Company.

(left) Aerial Paper Lead Cable carrying 13,800 volts; installation by Central Illinois Electric and Gas Co., Rockford, Illinois.

Cables...
means PROGRESS

(above) Baltimore Gas & Electric Company installation at large shopping center; direct earth burial cable, 2/0 triplexed 35 kv with neoprene jacket over individual conductors.

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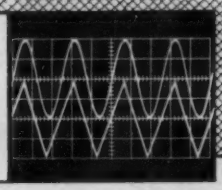
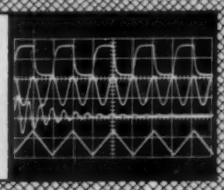
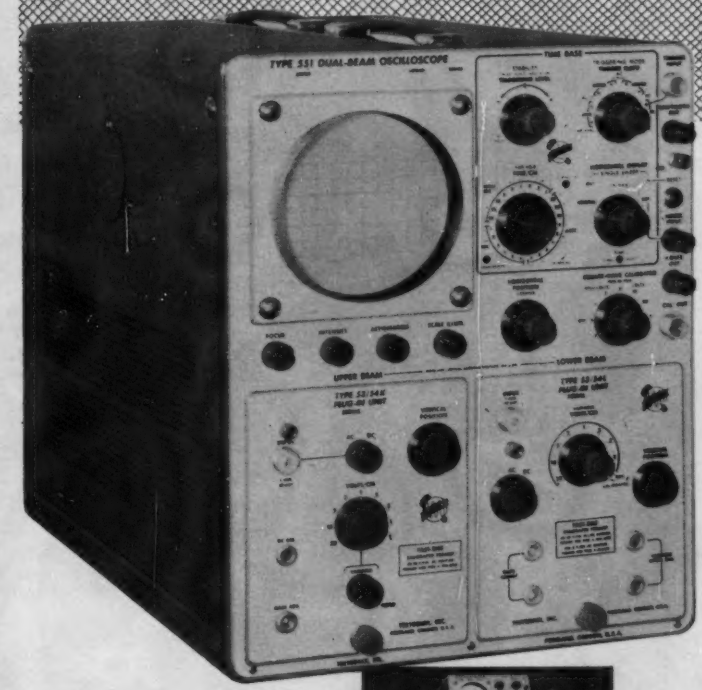




DC-to-25 MC



TYPE 551

When the job requires it, you can double up and display four different waveforms at once with this dual-beam oscilloscope. Type 53/54C Dual-Trace Plug-In Units in both channels make possible the four-trace display.

Less spectacular but more frequent uses of this versatile fast-rise oscilloscope include waveform comparison measurements on a dual-beam display in the dc-to-25 mc range, and all the usual and unusual applications of a high-performance laboratory oscilloscope.

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Passbands and risetimes with Type 53/54K units—dc-to-25 mc, 0.014 μsec.

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All Type 53/54 Plug-In Units can be used in both channels.

0.2 μsec DELAY NETWORKS

WIDE SWEEP RANGE
0.02 μsec/cm to 12 sec/cm.

SINGLE SWEEPS
Lockout-reset circuitry.

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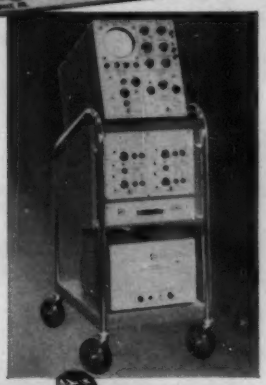
Fully-automatic or amplitude-level selection with preset or manual stability control.

10-kv ACCELERATING POTENTIAL
Brighter display for fast sweeps and low repetition rates.



PRICE
without plug-in units **$1725**
Type 500/53A Scope-Mobile **$108**
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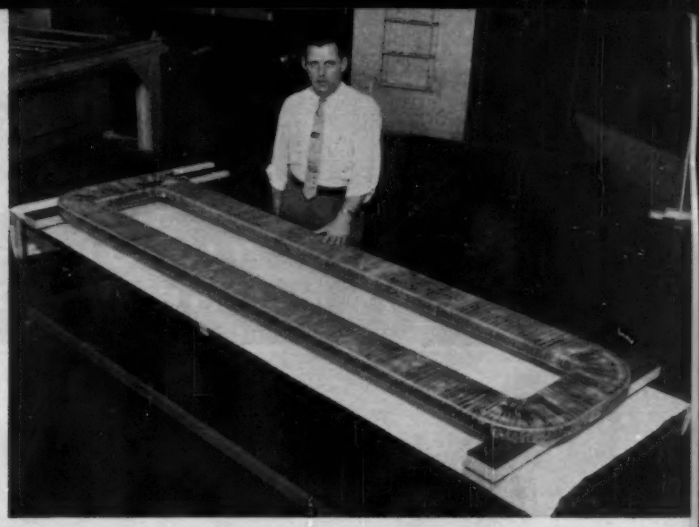
Tektronix is represented in 20 overseas countries by qualified engineering organizations.

National Supplies the Guide

for Brookhaven's 30 Billion Electron Volt

Magnet Coils

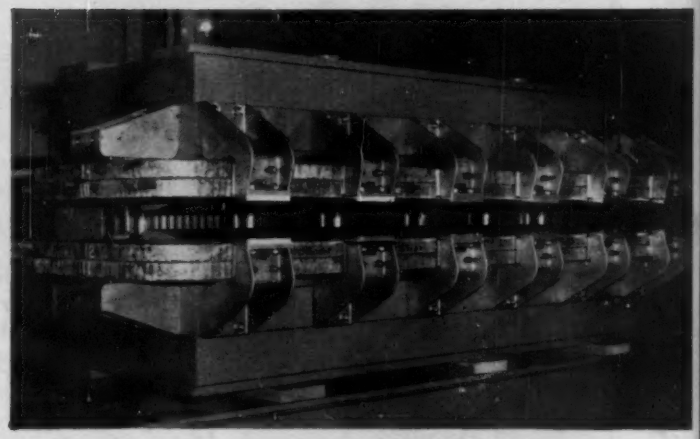
Proton Synchrotron



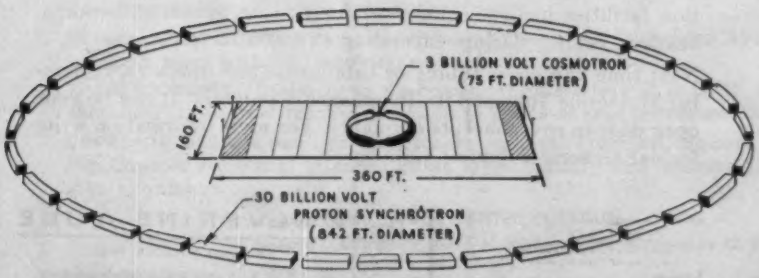
George LeVally, National design engineer, checks the surface finish of one of the nearly 1,000 National magnet coils made for Brookhaven. This coil is 108 inches long and weighs 780 pounds.

Nearly 1,000 National coils will be used in the giant particle accelerator under construction at Brookhaven National Laboratory. These coils energize the gigantic circular guide magnet which will give Brookhaven scientists precise directional control of protons moving at nearly the speed of light.

While the Brookhaven proton synchrotron is the largest research instrument for which National has supplied the coils, it is by no means the only one. National facilities for design, production and testing of special electrical windings for all types of research apparatus are at your service. For complete details on how these facilities can fit into your experimental programs, tell us your problem.



Four National coils assembled on a magnet core ready for installation in the Brookhaven proton synchrotron.



The drawing to the left shows the size of the new Brookhaven particle accelerator as compared to a football field and to Brookhaven's present cosmotron. The guide magnets are spaced around the half mile circumference to keep the protons in their circular path.

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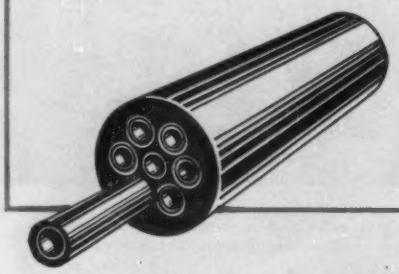
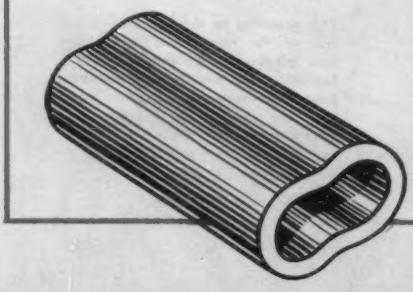
DEPENDABLE

TUBULAR PRODUCTS FOR THE ELECTRICAL INDUSTRY

This is Wolverine Trufin®—the integrally finned condenser tube that transfers more BTU's per foot of tube . . . is ideal for use in oil cooled transformers.



Ideal for transmission purposes is Wolverine small diameter tubing. This rigidly quality controlled product is available in copper, copper-base alloys and aluminum.



Wolverine copper and aluminum tube can readily be fabricated into electrical connectors such as that illustrated above.

For completely dependable tubing and tubular-shaped components your best bet is to work with a company that has made dependability a word to live by.

Wolverine Tube emphasizes the quality of the tubing and tubular-shaped parts it produces for electrical customers. All products are manufactured under a program of Tubemanship: statistical quality control, constant research, sound engineering and years of experience—skillfully blended together to insure Wolverine customers of top flight products—all the time.

Wolverine provides electrical manufacturers with both finned and prime surface condenser tube for transformer oil coolers. And for transmission purposes, Wolverine furnishes small diameter tubing in copper, copper-base alloy and aluminum. Wolverine's fabrication facilities include equipment for finning, spinning, bending, beading, coiling, flaring, expanding and extruding.

Next time you order tubing or tubular-shaped products, remember Wolverine Tube and its Tubemanship program. It can be your open door to new concepts of quality. For more information write for our General Products Catalog.

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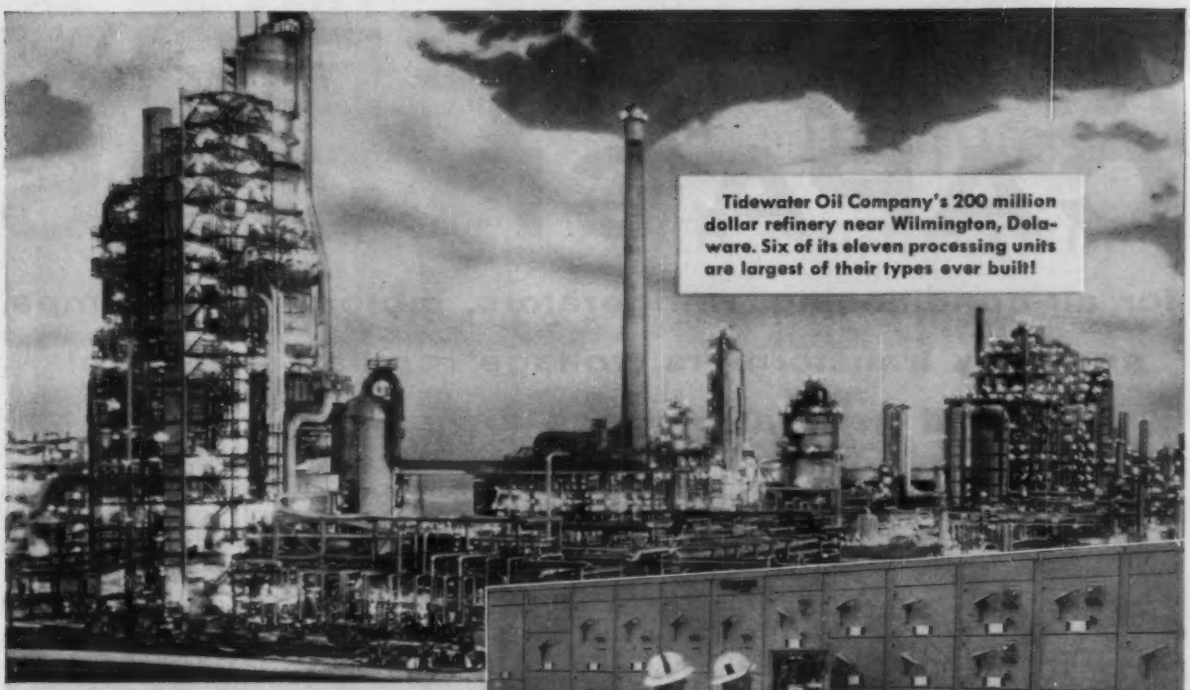
Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.



Tidewater Oil Company's 200 million dollar refinery near Wilmington, Delaware. Six of its eleven processing units are largest of their types ever built!

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INCREASED SAFETY! • Bus bars fully enclosed, rigidly supported and have ample cross section. Circuits isolated by individually enclosed plug-in units. Disconnect handle gives maximum operator protection.

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SPACE ECONOMY, TOO! • Up to six combination starters fit in a 20" x 90" section. Plug-in unit heights designed in space-saving increments of 3".

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Write for CONTROL CENTER BULLETIN...
Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.

(Top photo) In the refining area **Square D Control Centers** provide a portion of the centralized control of pumps and compressors. In the maintenance shop they control power, heating, ventilating and lighting.

(Lower photo) Another Square D Control Center, located in the Employe Relations Building, provides pushbutton control of air-conditioning units and compressors. Infirmary X-Ray equipment and parking lot lighting also are remotely controlled from this Center.

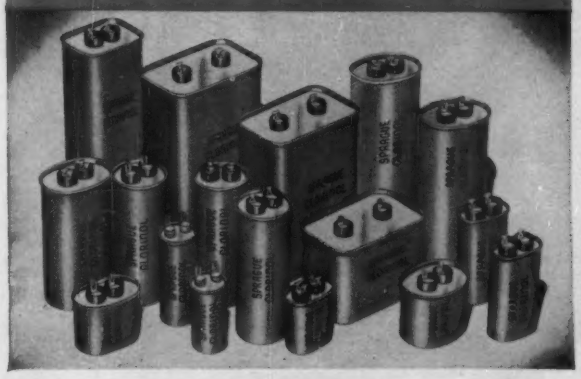
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

MOTOR-RUN CAPACITORS

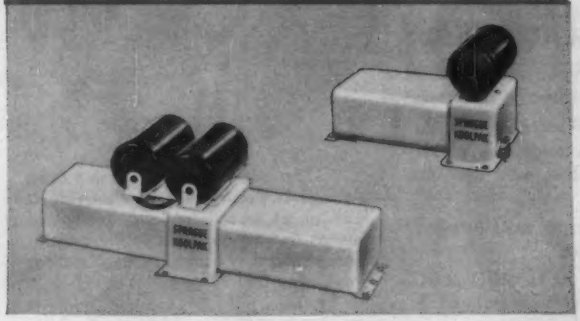
for air-conditioning, refrigerators, motors, heat pumps, specialty transformers, voltage regulators, controls, and general purpose a-c applications

CLORINOL® Capacitors



CLORINOL Capacitors are designed to save both space and weight and to help reduce costs in many typical a-c applications. Their drawn seamless steel cases make them extra sturdy, extra compact. They're made to resist corrosion . . . to take hard knocks and bangs . . . to withstand gruelling duty cycles. Double-rolled edges of the cover closure eliminate "pop-outs". The unique welded terminal assembly forms a dependable leakproof seal. The impregnant is a non-flammable synthetic liquid of high dielectric strength. Dual-blade universal terminals fit both popular types of female quick-connectors. Available in all the popular ratings and in three case styles—oval, rectangular, and cylindrical. Request Engineering Bulletins No. 4500 (general data), 4510 (oval), 4520 (rectangular), and 4530 (cylindrical).

KOOLPAK® Capacitor Assemblies



KOOLPAK Capacitor Assemblies provide complete motor-start and motor-run capacitance in one, easily installed unit that's perfectly matched to your requirements. The capacitors in each assemblyare completely exposed for cooler operation. The internal heat is dissipated quickly by conduction and convection. These cooler-running capacitors last from two to three times longer than those that are stuffed into conventional box packages. KOOLPAK assemblies cost you less because there's no outer box, no special leads or terminals to buy for interconnecting multiple capacitors. All units are finished to pass Article 207 of Underwriter Laboratories', Inc., requirements for air conditioners. Request Engineering Bulletin No. 4900A.

Sprague—*the world's largest manufacturer of capacitors*—has a complete line of motor-starting and motor-running capacitors. Write for Engineering Bulletins and application assistance. Address request to Technical Literature Section, Sprague Electric Co., 321 Marshall Street, North Adams, Mass.

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The Institute's 75th Anniversary Celebration

L. F. HICKERNELL
PRESIDENT AIEE

The new AIEE president describes the history, organization, and expansion of the Institute during the past 75 years. In his forecast for the future, President Hickernell expresses confidence that the Institute will keep pace with the unprecedented growth taking place in the field of electrical engineering.

DURING this administrative year, the Institute will be celebrating its 75th Anniversary. It is quite fitting that this historical observance be initiated at the 1958 Pacific General Meeting in Sacramento, Calif., a city itself rich in history of the nation.

Historians tell us that the City of Sacramento was first named in the advertisement of an auction sale of lots in October 1848, following the discovery of gold on January 24, 1848, by J. W. Marshall (1810-85) during excavation for a sawmill that he was building in partnership with J. A. Sutter (1803-80) on the latter's property. This precipitated the famous Gold Rush of 1849.

In the beginning, Sacramento was a canvas city, the first frame house having been built in January 1849. An act of legislature established Sacramento as the state capital on February 25, 1854.

Just 30 years later, and shortly after Edison placed in operation the first incandescent-lamp central station at Pearl Street, New York City (September 4, 1882, at 3:00 p.m.), our Institute was organized.

ORGANIZATION OF THE INSTITUTE

ORGANIZATION of the Institute was precipitated by the impending International Electrical Exhibition to be held under the auspices of the Franklin Institute at Philadelphia, Pa., during September and October 1884. Invitations having been extended to many famous foreign electrical personages, it was felt "it would be a lasting disgrace to American electricians if no American national society was in existence to receive them with the honors due from their co-laborers in the United States."

This quotation and other impelling arguments were contained in a circular issued by Dr. Nathaniel S. Keith in April 1884 calling for a meeting on May 13 to organize "The American Institute of Electrical Engineers." This "call" received 25 signatures; among them Thomas A. Edison, inventor; Norvin Green, president, Western Union Telegraph Co. (the Institute's first President, 1884-5-6); and George A. Hamilton, electrician, Western Union Telegraph Co. (Treasurer for 35 years, 1895-1930). The "call" was published in the April 15 issue of *The Operator*, the principal American electrical journal of the day.

On April 15, a preliminary meeting of the signers and others was held in the rooms of the American Society of Civil Engineers. "After some debate, the resolutions and whole scheme of organization were referred to a committee of 5." Incomplete records indicate that at least 71 charter members were enrolled.

At the organization meeting on May 13, the Committee on Organization proposed "a set of rules for the government of the Institute," which were read and adopted. These "Rules," in principle, still exist in our present Constitution, which has been amended 22 times. The annual dues were set at $10 for Associates and Members.

The Council (currently Board of Directors), recommended by the Committee, was elected, consisting of 21 members as follows:

President:
Dr. Norvin Green

Vice-Presidents:

Prof. A. Graham Bell	George A. Hamilton
Prof. Charles R. Cross	Charles A. Haskins
Thomas A. Edison	Frank L. Pope

Full text of an address presented at the General Session of the AIEE Pacific General Meeting, Sacramento, Calif., Aug. 19-22, 1958.

L. F. Hickernell is with the Anaconda Wire and Cable Company, Hastings on Hudson, N. Y.

Managers:

Frank W. Jones	Stephen D. Field
M. L. Hillings	Theodore N. Vail
William H. Eckert	Prof. Edwin J. Houston
W. W. Smith	Charles F. Brush
Prof. W. P. Trowbridge	Edward Weston
Prof. Elisha Gray	George B. Prescott

Treasurer:
Rowland R. Hazard

Secretary:
Nathaniel S. Keith

The Directors of the International Electrical Exhibition tendered to the Institute the free use of rooms in the Exhibition Building, which were visited by many members and by several foreign "electricians."

EARLY MEETINGS

ON OCTOBER 7-8, the first meeting for reading and discussion of papers was held at the Continental Hotel and the Exhibition Building rooms at Philadelphia. Eleven papers were presented and discussed. It is interesting to note that the first published paper was on the Edison effect, which laid the foundation for modern electronics.

Upon invitation of the Franklin Institute, the Exhibition was inspected by the members in a body. Probably this was the first of the "inspection trips" which ever since have been a feature of the General Meetings.

At the 1st Annual Meeting, May 19, 1885, the treasurer presented a "Summarized Account," which is interesting to compare with the latest financial report:

	May 19, 1885	April 30, 1958
Income	$2,315	$1,759,876
Expenses	1,455	1,674,563
Balance	$ 860	$ 85,313

At the General Meeting the next day (May 20, 1885), 5 papers were presented and discussed, bringing the total to 16 papers during 1884-85. For the fiscal year 1957-58, 2,159 papers were presented at 4 General Meetings, 4 District Meetings, and 27 Special Technical Conferences; and uncounted thousands at 2,606 Section, Subsection, Technical Group and Joint Meetings. From 1884 to 1958, the membership has grown from 71 to 52,213.

At both the 1st and 2nd Annual Meetings (May 19, 1885 and May 18, 1886), the secretary proposed that monthly meetings be held because he believed "it is essential to the welfare of the Institute that we should get together oftener than once a year, and become acquainted with each other and make our existence manifest (applause)." After some debate, a Committee on Monthly Meetings was appointed, later reporting it considered "such an arrangement desirable."

The first of the monthly "Special" meetings was held on June 8, 1886; the second on December 7. No meetings were scheduled during the summer "when everybody goes out of town, and people prefer to loll on verandas with palm-leaf fans in their hands to getting together in meetings."

Monthly meetings continued to be held only at New York City until March 21, 1894, when arrangements were made for western members to hold simultaneous meetings at Chicago, Ill. Under this plan, the same paper was presented and discussed in both cities.

SECTIONS AND BRANCHES

THIS PRACTICE continued until 1902, when local meetings in other cities and universities, later organized under Sections and Student Branches, were authorized. During 1902, Chicago and Minneapolis, Minn., held 6 meetings with an attendance of 500. Presently, there are 112 Sections, 67 Subsections, and 223 Technical Groups which, in 1957-58, held 2,606 meetings with a combined attendance of 137,373.

In 1903, 9 Student Branches held 104 meetings with an attendance of 3,450. During 1957-58, 157 Branches held 1,374 meetings with an attendance of 87,477.

TECHNICAL ACTIVITIES

THE FIRST RECORDED DEPARTURE from presentation and discussion of papers was at the 2nd Annual Meeting (May 18, 1886) when the Institute was requested to join the National Electric Light Association (NELA) in an endorsement of a New English Standard Wire Gauge. After debate, a committee was appointed, but there is no record that the endorsement was ever made.

On December 3, 1889, the Council appointed a committee "to formulate and submit for approval a Standard Wiring Table for lighting and power purposes." The Committee submitted a preliminary report which was amended at the September 16, 1890 monthly meeting. A revised report, presented at the November 18, 1890 meeting, was ordered printed for consideration by distant members. Subsequently, the Table was approved and entered into engineering practice.

At the September 16, 1890 meeting, a resolution was adopted "that the name of Henry should be given to the practical unit of self induction, since he was the discoverer and greatest investigator of this phenomenon." This was referred to the 1893 International Electrical Congress which met during the World's Fair at Chicago, and was adopted.

In June 1891, a standing Committee on Units and Standards was appointed (A. E. Kennelly, chairman) and the Institute embarked upon one of its most important contributions: the preparation of Electrical Standards.

At its 2nd Meeting, June 3, 1884, Council appointed standing Committees to cover the apparatus and subjects of that time. These, like other early committees, were short-lived, the committee organization changing from year to year.

The first technical committee of the type now functioning, Power Transmission and Distribution (R. D. Mershon, chairman), was organized in 1902 as a subcommittee of the Meetings and Papers Committee.

During 1957-58, there were 56 Technical Committees, 234 Committees, and 53 Working Groups, with a composite personnel of 6,210. In addition to their prepara-

tion of standards and other technical activities, these committees sponsor the papers presented at General and District Meetings and at Special Technical Conferences.

PUBLICATIONS

In 1884, "printing" expenses were $594.26, primarily for 1,000 copies of the first volume of *Transactions*, published in March 1885. For 1957-58, publication expenses were $826,576, about half the total income.

Currently, the Institute publishes

Electrical Engineering (monthly)
Bimonthly periodicals and *Transactions* (annual):
- Part I. Communication and Electronics
- Part II. Applications and Industry
- Part III. Power Apparatus and Systems

Preprints of papers
Membership Directory (annual)
Organization Manual (annual)
Special publications

The latter include bibliographies, symposia, conference proceedings, and similar material.

ORGANIZATION

Until 1947-48, all General and Technical Committees reported directly to the Council (1901, Board of Directors). In 1947, the technical activities were expanded, and the committees were grouped into Divisions, chairmen of which formed the Technical Advisory (later Technical Operations) Committee.

For 1956-57, the District-Section-Branch Organization ("line") was augmented by 5 Departments ("general staff"), viz.:

Administration
Admission and Advancement
Professional Development and Recognition
Publications
Technical Operations

These, together with the "Board" Committees on Finance, Constitution and Bylaws, and Planning and Coordination, comprise the current AIEE organization.

On June 27, 1958, the Board of Directors authorized an "Institute Services" (headquarters) staff to service these Departments adequately, one of the most constructive steps taken in a long time.

With some modifications, it is believed that this organization plan is adequate to service a future membership of 100,000. The headquarters staff organization will be housed in the new United Engineering Center in New York City.

ANNIVERSARY CELEBRATION

A committee has been appointed (Dixon Lewis, chairman) to modestly celebrate the Institute's 75th Anniversary during the year 1958-59. A general plan has been formulated. As details are completed, they will be announced in *Electrical Engineering*, and at all Institute meetings. The organization (May 13) and first technical meetings (October 7-8) will be celebrated appropriately by the New York and Philadelphia Sections on or about these historic dates.

However, it is the intention of the Committee to use history only as a springboard to the future. To emphasize this viewpoint, the slogan adopted for the anniversary is

75 YEARS—*A Prologue to the Future*

In May or June 1959, a special commemorative edition of *Electrical Engineering* will be published to bring up to date the 50th Anniversary issue (Vol. 53, no. 5, May 1934—"The Gold Book"). Eminent authors are being urged to supplement the 25-year reviews with their predictions of future developments in their respective fields. In addition, other events and special features are being developed to emphasize the anniversary theme.

THE INSTITUTE'S FUTURE

Prediction of the future is a risky business, as indicated by two famous quotations:

1. In 1889, Thomas A. Edison said, "there is no plea which will justify the use of high-tension and alternating current in either a scientific or commercial sense . . . my personal desire would be to prohibit entirely the use of alternating currents. They are unnecessary as they are dangerous."

2. When plans were considered for using Niagara Falls as a source of power, Sir William Thomson (Lord Kelvin), president of the International Niagara Commission, cabled, "Trust you avoid gigantic mistake of adoption of alternating current."

Fortunately, the many outstanding accomplishments of these pioneers far outweighed their error in judgment in choosing sides in the great battle of "Ac vs Dc."

In the 50th Anniversary edition of *Electrical Engineering*, Past Presidents J. B. Whitehead (1933-34), C. F. Scott (1902-03), and others confined themselves primarily to the Institute's past in which many of them played a prominent part. In concluding their articles, some of them referred to a promising future in general terms. Needless to say, no mention was made of the possibilities of nuclear power or space vehicles—developments within the past 25 years.

Being no more clairvoyant than my predecessors, I am in no better position to foresee specific future developments in the electrical and allied arts. However, as a member of an industry which spends billions each year on research and development for military and civilian purposes, I am confident that we are entering an era of unprecedented growth.

Will the Institute keep pace with this growth? It now has the machinery and flexibility to do so. Whether or not it is able to meet the challenge of rapid developments in technology, and changing patterns in human living habits, depends upon its ability to attract groups of men dedicated to its welfare and the profession which it represents. It has never failed to develop such leaders in the past; I have no reason to doubt its ability to do so in the future.

Silver Plated Aluminum Bus Conductor

C. E. BURLEY
ASSOCIATE MEMBER AIEE

SURFACING ALUMINUM with a high-quality silver plating eliminates many of the joining problems which have limited the application of aluminum bus conductor. These problems are related to the natural oxide film on the surface of the aluminum and to the possibility of galvanic corrosion in aluminum–copper connections.

Establishing as a goal the concept of a single product that could be used economically in a maximum number of applications, the Metallurgical Research Laboratories of Reynolds Metals Company set out to develop a commercial process for silver plating aluminum bus. The following quality requirements were established: there must be excellent adhesion between the plating and the base metal; the plating must be free of porosity; the plating must have good resistance to abrasion; and the plating must have maximum formability consistent with adequate corrosion resistance.

Exploratory study showed that multilayer zinc–copper–silver plating offered the most promise for a satisfactory product, and a pilot plating line was set up to study the variables in the zinc–copper–silver process.

Process evaluation was based on the chemical, electrical, and mechanical properties of plated bus bars. Results were judged by absence of blistering during and after the plating operations, uniformity of color and appearance, measurement of joint resistance before and after accelerated corrosion, determination of temperature rise of joints during cyclic current loading, formability of plated bus in bend tests, abrasion resistance of silver platings, and corrosion resistance of flat and bent areas in accelerated water fog spray tests.

The evaluation program showed that the physical and chemical properties of silver plated aluminum conductors depend upon surface preparation of the bare aluminum, plating bath compositions, and plating thicknesses. The developed process provides sufficient copper to meet the requirements of a pore-free surface. Silver thickness was chosen to meet the requirements for good abrasion resistance, low joint resistance, and minimum cost. Although greater corrosion protection could be obtained with a thicker copper plate, formability would be reduced. A compromise has been made in order to produce a versatile product for general use by the electrical industry. For outdoor and severe corrosive environments, additional protection of the plated conductor will be required.

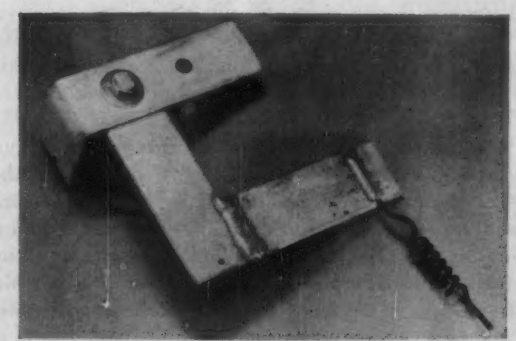


Fig. 1. Joining methods used with silver plated bus.

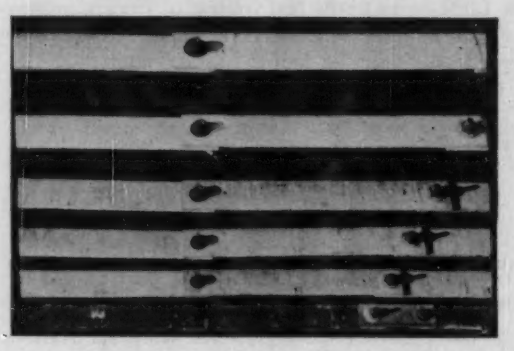


Fig. 2. Close-up of bars and joints in atmospheric-cyclic loading tests. The two rows of bars at bottom were plated by the Reynolds process.

The electrical characteristics of this product are excellent and meet all known standards.

Rectangular bus up to ½ inch thickness can be bent flatwise with bend radius equal to bar thickness without flaking of the plating and with only minor cracking.

Satisfactory resistance to corrosion can be expected for all but severe conditions.

Joints can be made by bolting and welding, and copper and aluminum wire may be soldered or brazed to the plated bus with no special surface preparation. Representative techniques are shown in Fig. 1.

After six months of outdoor exposure in Richmond, Va., bolted joints made from "a plated" bus have maintained their initial stabilized resistance values, and there has been no undercutting of the platings at exposed edges or evidence of peeling. A view of some of these conductors is given in Fig. 2.

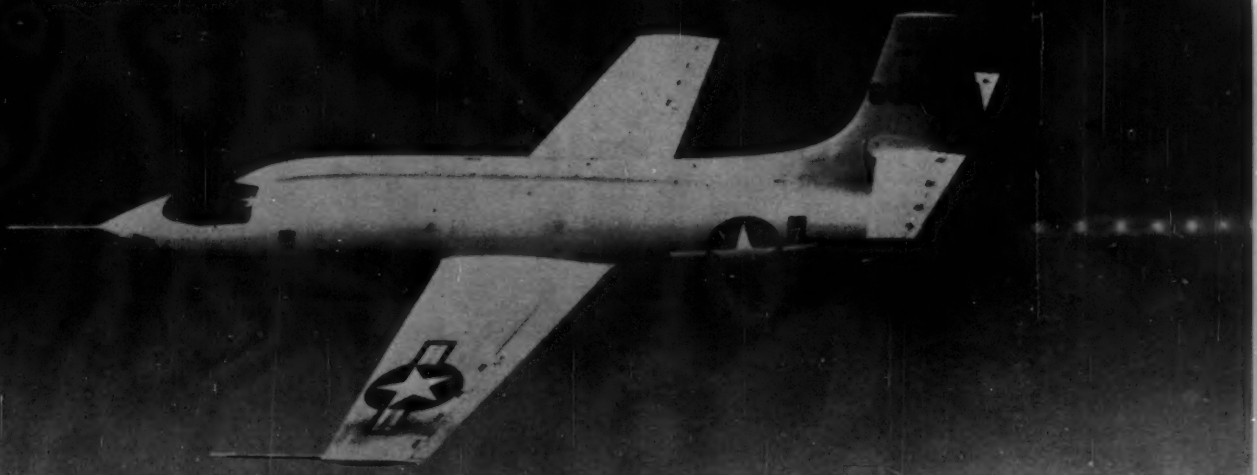
Commercial availability of a quality silver plated product should encourage engineers to consider aluminum bus in applications where joining problems have previously discouraged its use.

Digest of paper 58-873, recommended by the AIEE Substations Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N.Y., June 22-27, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

C. E. Burley is with Reynolds Metals Company, Richmond, Va.

Electrical Frontiers in Space

LESTON FANEUF



With the coming of the Space Age, electrical engineering has erupted in the field of aviation. Rockets, supersonic flight, navigation and control systems, missiles, and satellites, have so intertwined the two fields that a new major division of engineering activity called "avionics" has been created.

TWO SHORT DECADES AGO a gathering of electrical engineers such as this would not have been a very likely place to find an executive of the aviation industry.

As a matter of fact, even an appearance before a group of production engineers might have been highly inappropriate, inasmuch as 1938 was not noted for the number of aircraft produced in this country.

But, in those days, as today, the financial problems of much of the aircraft industry were serious and time consuming. Aviation industry executives spent a large amount of their time making presentations to bankers and other persons in the financial fields.

While such presentations are still necessary and frequent, aviation's management has had to broaden its scope immeasureably in order to keep in step with the rapidly changing complexion of its industry.

Up through the years prior to World War II, the electrical engineer played a relatively minor role in aviation. Today, in an age of jet propulsion and rockets, supersonic flight, navigation and control systems, missiles, and satellites, electrical engineering and aviation find themselves inseparably intertwined.

By way of illustration, the first thing that comes to mind is the name of a large division of our company. We call this the Avionics Division and as you are all aware, avionics derives from the contraction of "aviation electronics" and is the only completely appropriate title to define a major division which concerns itself with the problems of electronics, electrical design, and servomechanisms in missiles, aircraft, and space vehicles.

Regardless of what they call it, almost all major members of the country's aviation family have established avionics divisions, have purchased electronics companies, or have developed intimate business relations with outstanding organizations in the electronics field.

A good example is the Martin–Bell team that is sharing with the Boeing team the first phase responsibility for the DYNA-SOAR Program. Associated with Martin and Bell are Bendix, Minneapolis-Honeywell, and Goodyear Aircraft—all in electronics capacities.

As you may be aware, DYNA-SOAR is the name the U. S. Air Force has applied to its first hypersonic boost glide space vehicle, now under development.

Essentially full text of an address delivered before the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N.Y., June 22-27, 1958

Leston Faneuf is president of Bell Aircraft Corporation, Buffalo, N.Y.

EXTENSION OF HUMAN CAPABILITIES

MUCH OF THIS EMPHASIS is caused by the necessity for supplementing the capabilities of a human being in the manned aircraft that each year fly higher and faster. Electrical or mechanical devices associated with servomechanisms amplify the capabilities of human strength as well as allow applications in areas impossible for the human body to reach or faster than the human mind can react.

The availability of power in small packages has expanded the muscles of a pilot to permit him to master the tremendous forces his aircraft encounters. Complex electric circuits supplement his intelligence by defining programs and procedures, by predicting and anticipating requirements, and even by supplementing his memory, as well as communicating and storing technical data.

Carried to a reasonably normal conclusion, this tendency toward uniting aviation and electronics is exemplified distinctly in the field of guided missiles and in our coming Space Age.

In a guided missile, the human being is relieved entirely of the routine operation of the vehicle. Relieved in this way, he can concentrate on other significant problems, techniques, alternatives, or even over-all policy in utilization of such devices.

On the other hand, in the DYNA-SOAR space vehicle, a man or a crew of men is necessary.

At speeds of 18,000 mph and at altitudes of 100, 200, 300 miles, and higher, a pilot and a crew will require the most advanced, the most precise type of electronic systems—systems coming as close to the human nerve system as possible.

Human beings will be aboard these vehicles not so much for the job of piloting and navigating as to make adjustments or repairs and to be in a position to override the automatic controls in cases of unpredictable emergencies or suddenly changed requirements.

AVIATION NOW THREE DIMENSIONAL

DURING THE PAST SIX OR SEVEN MONTHS one of the most significant breakthroughs in the technical progress of man has taken place. The Soviets achieved this milestone with their Sputniks, followed closely by the Explorer and the Vanguard satellites of the United States.

With its long history of "firsts" in aviation, our own company is particularly conscious of breakthroughs of this sort, because we have been directly associated with three such important breakthroughs in recent years.

Bell Aircraft built and flew this country's first jet airplane, the *XP-59*. This was flown in October 1942, exactly one year after the then U. S. Army Air Forces asked us to produce an airframe compatible to a jet engine which was being built along the lines of the Whittle engine in England. And, incidentally, it was basically an electric company that built this first United States jet engine—General Electric.

The breakthrough into supersonic flight was established in the Bell *X-1* (Fig. 1 at start of article) in October 1947, in the face of many critics who contended the sonic barrier was beyond the capabilities of man. The *XP-59* is shown in Fig. 2.

Six years later, another Bell airplane, the *X-2* (Fig. 3) lifted further the lid on the strongbox which had locked away for centuries the secrets of space. The *X-2* flew at a speed more than three times that of sound and reached an altitude of more than 126,000 feet, still the fastest and highest marks ever made by a manned airplane.

The most recent breakthrough, the successful orbiting of satellites, has opened wide the realm of space exploration and, at long last has given aviation a truly three-dimensional medium.

Thus, at a time when the entire aviation industry is actively pursuing techniques and devices for making this breakthrough into space a true conquest by putting man into space and bringing him back safely, it seems appropriate to discuss with you the topic I have chosen for today "Electrical Frontiers in Space."

Communication with living beings on another planet has long been a favorite theme of science-fiction writers. Attempts have been made to establish the existence or nonexistence of "men" on Mars in terms of signals which have or have not been received from that planet. Inherent in this is the realization that the ability to communicate is essential to the exploration and utilization of any new medium.

This is true whether the vehicle exploring the unknown contains a man or whether it consists merely of a lifeless probe.

KEY ROLE OF COMMUNICATION

IN EXPLORATION OF SPACE, communication is fundamental to the acquisition and interpretation of significant information. In such a program, the ingenuity of the electronic designer is taxed to the limit. Problems of range through which signals can be transmitted, antennas, and even the acquisition of the necessary information by instruments have demanded and will continue to demand clever solutions.

Solutions to these problems are made much more

Fig. 2. A view of the United States' first jet airplane, the XP-59.

Fig. 3. The X-2, successor to the X-1, still has the fastest and highest marks ever made by a manned airplane.

critical because of the drastic weight limitations imposed by the very nature of space exploration, particularly with present-day power plants. Vehicles with take-off weights from 250 to 1,000 pounds per pound of orbital payload are required to attain orbit. It is this present brute force requirement which has made Soviet Union successes so impressive.

On the other hand, the ability of engineers in this country to design electronic equipment in very small packages by the clever use of miniaturization has not been duplicated by the Soviets, we believe. Their approach in this area is also by massive force, thus requiring the heavy vehicles which they have put into orbit.

If a vehicle is passing through even very rarified air at extreme speeds, some peculiar phenomena take place. Our aerodynamicists are forced to become experts in physics, and we all have aerophysics groups.

The peculiar phenomenon of greatest challenge is the ionization of this rare atmosphere caused by the high speeds and temperatures of the object passing through. How electromagnetic radiation can be transmitted satisfactorily through this layer surrounding the vehicle is a matter of grave concern, as you well know.

A communication system for a vehicle of this type places extremely high demands on reliability of components. Successful operation of complex devices over long periods of time implies that each tiny part may have to be capable of operating not hundreds, but perhaps millions of hours on the average without failure, barring predictable wear-out.

It is likely that one of the most significant roles which a human being can play in a space vehicle is application of decision-making when certain elements of equipment fail.

The human, for all his complexity, is still a highly reliable item, efficient, requiring little power, capable of adjusting to the unusual, and relatively free from jamming. And speaking of miniaturization, with a volume of two pints and a weight of two pounds, a man's brain is a remarkable and versatile instrument package.

This problem of reliability is of critical concern to the management of programs involving space. Satellites and space stations will not be produced in quantity like electric refrigerators or radios or even in the same numbers as airplanes. The cost of these devices is so great that failures will be difficult to justify.

How then can complex equipment be designed and produced without the benefit of a "learning curve" and with all the pressure such critical and costly programs present?

Design of equipment must frequently be accomplished without actual experience regarding the environment in which it must live. The proper balance between analysis and experiment, between prediction and trial, between conservatism and risk—all these are fundamental problems in the management of programs to conquer space.

Communication actually consists of much more than merely the sending and receiving of signals. Accurate information must be transmitted, preferably information of significance. The acquisition of such information, its preparation or coding, actual transmission, decoding—all these are of little significance if the data cannot be properly interpreted.

Millions of bits of information can be accumulated during only one passage of a satellite. In evaluating this output, drastic methods for assisting the human intelligence in absorbing this material are necessary.

It is an unusual challenge to the electrical engineer to devise methods of information retrieval which spotlight items of significance and properly process them for human comprehension.

We are usually interested in the unusual, the unexpected, and only if such data can be correctly extracted and evaluated is there much hope of accomplishing the scientific job intended.

I am sure I do not have to tell you that the Niagara Frontier has been and continues to be not only a pioneer but a most exciting area in the field of electric power. The development of generating devices from water wheels in a power canal to the highly efficient turbines and pumps of the mammoth new Niagara project now being built by the New York State Power Authority—the expansion of a single power line carrying the first alternating current from Niagara Falls to Buffalo into a network of transmission lines covering not only New York State but connecting with the entire eastern part of this country and Canada—these are exciting and significant in the field of electrical engineering.

POWER IN SPACE

THE UTILIZATION OF POWER IN SPACE far removed from conventional sources implies the opening of as significant an electrical frontier as the early Niagara generation and transmission.

The first of Bell's guided missiles many years ago carried in batteries sufficient electrical power for a short flight. As the power requirements increased, it became

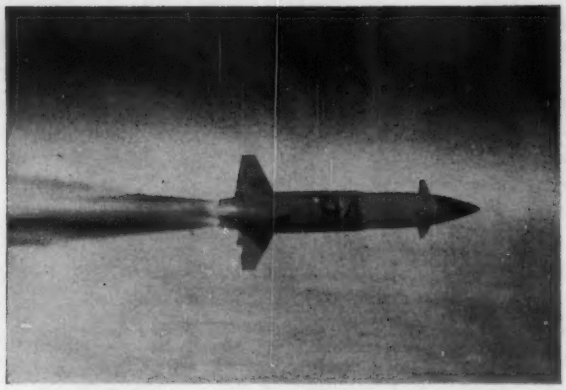


Fig. 4. U. S. Air Force air-to-surface guided missile, built by Bell Aircraft Corporation, streaks toward distant target after being launched from a B-47 bomber.

necessary to install generators driven by a gas turbine. Neither of these concepts are very satisfactory for vehicles in which low weight and long duration must be combined.

Because most such missile and space equipment requires a source of electric power for its operation, the development of auxiliary power units for use in space becomes a major requirement of any such program.

Numerous suggestions have been proposed, as you know, and many are being actively pursued. Away from the cloud cover of the Earth, the possibility of using solar energy seems to become highly feasible. This may require large surfaces extending out from the vehicles; of course once the object is in outer space the drag forces on such projections will not be critical.

The possibility of transmitting energy from the ground has always been intriguing, because of the ability to control closely the power source, but indications of progress in this direction are very slight, especially when the flight object is relatively small and so far away.

Nuclear power, of course, holds real potentiality if weights and volumes can be drastically reduced. The direct conversion of nuclear energy into electric power without the intervention of turbines and generators is perhaps the ultimate answer.

To date, access to space generally has been attained by the use of large liquid propellant rockets to place a vehicle in a trajectory or an orbit. Even if the ultimate efficiency of liquid or solid propellants is obtained, the time required to travel from the Earth to the moon or the nearest planet is a major factor.

Both liquid and solid rockets for applications of this type burn out quickly; in order to attain shorter travel times, some force probably should be applied continually during a space flight. Such a force need not be large, in fact, only a small percentage of take-off thrust would be required.

Considerable research at the present time is being carried out regarding the use of charged particles to accelerate the space vehicle. Small amounts of thrust have actually been produced in laboratories by ionizing matter and accelerating it through magnetic or electrical fields.

Power requirements, so far, have been extremely high since a full-scale generating facility was necessary to accelerate the charge particles and produce even a few pounds of thrust.

Again a nuclear electric generating plant may supply the answer, although the size as presently estimated will be very large.

It must be recalled however, that liquid fuel rockets have a history of only 32 years. The 184 feet through which Dr. Goddard's first rocket traveled in 1926 is somewhat trivial when compared with a 3,000 pound Sputnik placed in orbit by liquid rockets in 1958. If such a rate of progress exists in ion propulsion, the era of 1980 could well bring forth some drastic developments, in the opinion of our power plant people.

NAVIGATION AND CONTROL IN SPACE

PRESENT ORBITS OF SATELLITE VEHICLES are defined completely by the initial conditions imposed during launching and by the properties of space—the environment in which they fly. The true conquest of space can only be attempted when man can determine his position at any instant and control his course.

Certainly, if we are to put a man in space, he has to know where he's going, where he's been, where he is, and how he is going to find his way back.

This is true not only for a manned vehicle, in which one of the necessary properties will be the ability to return to the Earth at any desired time and in any specific place, but even for unmanned vehicles.

This concept of the importance of navigation and control in space has been fundamental to the work at Bell on the *X-1*, the *X-2*, missiles, and now DYNA-SOAR. We have not been interested in sacrificing a man within the nose-cone of a missile for scientific prestige. Probing the fringes of space with controllable vehicles has seemed to be a logical and inevitable approach.

The ability to modify a flight path in space is the property which determines that man is master, not slave. Orbits or paths should be optimized, interception either for friendly or hostile purposes must be possible, and control near the Earth or a celestial body is essential. For reconnaissance purposes, the orientation of the vehicle should be accurately maintained for optical or radar coverage. Most of this problem must be referred to the electrical engineer for solution.

When aviation was young, the pilot flew "by the seat of his pants." He could tell when he was climbing or diving, when he turned, and, if he were experienced, by how much.

Today we require much more sophisticated devices, working, however, on much the same principle—inertial.

Inertial guidance systems are a highly complex coordination of electrical and mechanical devices used in many of our aircraft and missiles, and essential in our navigation through space. The use of star-tracking devices which automatically determine the position of

stars or planets and compute from these the position of the vehicle, will likely also play a significant role in space flight.

It seems essential that the navigation for a true space ship must be self-contained rather than dependent on information relayed from the Earth. System designs for space navigation are only now beginning to be laid down; the problem is obviously much more difficult than indicated by this brief and oversimplified comment regarding it, but with this difficulty there is also associated the tremendous significance of each small accomplishment.

To many individuals, in every age, it has at times seemed certain that the limit in scientific development has been reached. This is less true among those individuals who have been associated with the development of the explosively expanding fields involving electrical engineering.

Even here, however, there may come times when intensification of a development, wider applications, more efficient production and use, and other such properties seem much more significant than basic new ideas. The frontiers in space exist as denials to this attitude. Technical horizons are not fixed, even in space.

A few of these frontiers involve areas of particular interest to such a group as yours. The astronomer of a generation ago was only interested in the lenses and mirrors which could gather visible light. A shift to photographic plates gave interest to an extension of this spectrum.

Today, we realize that a study of the radio emanations from celestial bodies can be a highly significant part of astronomical research—and a further clue as to what and why space is and does.

The loss of electrical resistance at temperatures approaching absolute zero is a recent and exciting laboratory phenomenon. Space temperatures approach this.

At the same time that low temperatures are of interest, aerodynamic heating during ascent and descent through the Earth's atmosphere places requirements for ultrahigh temperature capabilities.

Add to these the research suggested by developments in solid-state physics, interactions between radiation and electrical phenomena, the radically different manufacturing techniques required for simplicity and high reliability, and magnetic and electrical interactions in space around the Earth—all these are highly pertinent areas of research which will provide the limitless horizons of scientific development in the future.

The conquest of space is being accomplished. Contributions from all scientific and industrial sources are significant. The problems being encountered are an exciting challenge—are steps toward totally new areas of interest. The excitement and romance of a frontier lies not in its known potentialities, but in its unknown promises.

For the American Institute of Electrical Engineers, and for all scientific and technical organizations, the frontiers in space are the challenge of today and the promise of tomorrow.

Managing Versus Manipulation

H. H. RACE
FELLOW AIEE

The profession of Managing is moving away from the paternal and coercive manipulation of individuals toward a social concept of power which rests on the dignity and worth of all individuals in the organization. Leadership thus exercised will produce the greatest usefulness and profitability.

PREVIOUS ARTICLES have touched on certain foundations or assumptions underlying Managing as a significant, valuable and unique kind of work in a business enterprise which is worthy of study as a career and a profession.[1-6]

A key thought is that men in business enterprises throughout the free world are hammering out, in practical working situations, the conditions under which an individual may grow, his individuality be enhanced and recognized and, at the same time, groups of individuals can learn to work together ever more effectively in concerted action. Thus:

1. Each individual, exercising initiative and self-discipline, can achieve greatest total work satisfaction by making his unique contribution to the output of the whole enterprise.

A special article recommended for publication by the AIEE Management Committee.

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2. The group can achieve greatest total long-run productivity immeasurably greater than can be accomplished without concerted action.
3. All will benefit most from the contributions of each.

This thought is based on the belief that as social beings most employees will work more strenuously, contribute more wholeheartedly and approach ever closer to their collective productivity potential when certain vital conditions are met in the business enterprise in which they are employed. In other words, each employee's loyalty and effectiveness of voluntary effort in a business enterprise will vary directly with the degree to which he believes that: (1) objectives are ethically, socially, and economically progressive and sound; (2) policies are just and in the public interest; and (3) practices, in fact, do lead to outstanding economic performance and, at the same time, do provide opportunities for the exercise of personal initiative and do provide personal rewards commensurate with personal contributions and personal growth.

The aim of this article is not to attempt to justify the foregoing expressed thought or belief, but rather to explore some of the ideas that need to be studied and understood by managers who are responsible for setting such objectives and policies and carrying out such practices.

POSITION OF RESPONSIBILITY

WHENEVER INDIVIDUALS join together to accomplish desired results through concerted action, there is necessarily an assemblage of the contributions of the individuals involved. Man has learned that concerted action does not happen by chance. Concerted action requires planning, organizing, integrating, and measuring the work and results of individuals and of groups. Furthermore, concerted action requires someone in a position to make whatever decisions are necessary so that all concerned do work in concert toward common goals. These are positions of leadership and the person occupying such a position may be (1) self-imposed as in a political dictatorship, or (2) elected as in a political democracy, or (3) selected by higher managers as in the case of a business enterprise.

The prime point to be made is that leadership positions (except in the case of the self-imposed dictator) are built up of sets of responsibilities for the accomplishment of specific results and the leader is accountable for such accomplishment to the person or group that elected or appointed him to that position.

POSITION OF POWER

BECAUSE A MANAGER is responsible for making decisions which are essential to achieve desired results through concerted action and because he is correspondingly held accountable for the accomplishment of these results, he necessarily exercises power commensurate with such responsibilities and with the impact of such decisions. In a business enterprise, this power of position resides in the position holder's right to ask for and expect certain actions on the part of those who report to him. The scope and limits of this power are defined through the process of delegation by which working agreements are made between him and the manager to whom he reports, all within over-all company plans and policies. These working agreements include, as inseparable commensurate facets, the assignment of responsibilities (with defined scopes and limits of work to be done), the transfer of all authorities necessary to get the work done, and the voluntary acceptance by the incumbent of the position of the obligation of accountability to his manager for satisfactory performance of the work assigned to his component. Making decisions with regard to the work being done is the chief vehicle through which a manager exercises his power of position.

A manager's job is to become expert and proficient at providing the working climate and the organizational relationships for aggregate concerted action in the component for which he is responsible. Combining responsibility and work brings purposefulness to the expenditure of energy.

These statements have been made to show that it is taken for granted that a manager has power and that positions of power are necessary for concerted action in a business enterprise. Prestige, status, even national acclaim accrue to men who rise to positions of greatest responsibility and, hence, greatest power in our business enterprises. But power can be used wisely or unwisely—for good or for evil. There is no question about the existence of power-packed positions. The wise use of power is necessary in present-day society. It is not a concept from which to hide or shy away. The moral–ethical–social value judgments of "good" or "bad" depend upon the objectives, knowledge, ability, wisdom, and integrity of the manager and upon the point of view of the judge. Therefore, the question is not how much power does a manager have, but rather, how and according to what motivation does a manager use his power.

Several quotations will be used to amplify these points.

George Bernard Shaw:[7]

"Power does not corrupt men; fools, however, if they get into a position of power, corrupt power."

Woodrow Wilson:[7]

"Human nature is much the same in government as in the drygoods trade. Power and strict accountability for its use are the essential constituents of good government."

Robert Strausz-Hupe:[8]

"In human relationships, power signifies the power of man over man and such power over things as contributes to the power of man over man. Power is, therefore, what men think, say, and do about power. Hence power, unqualified by human motiva-

tion and the properties of specific human relationships, is a meaningless notion. The meaning of power lies in what is is used for or, rather, in beliefs men hold about intentions and purposes animating its use. There is a fundamental distinction between a political philosophy that seeks to evolve principles for the control of power within the context of social relationships and one that raises power to the first principle of social evolution. The former views power as a means to an end, namely the ordering of society in the image of a more perfect state of human relationships; the latter, since it recognizes no other effective human motivation, must ultimately view power as an end in itself."

Lasswell, Merriam & Smith:[9]
"The birth of power is found in:

"1. Types of social situations requiring balance and equilibrium among groups.

"2. Types of human personalities requiring adjustment and adaptation, across group lines, perhaps.

"3. The aptitudes and capacities of power-hungry personalities with an urge for the organization and exercise of authority."

Alford and Beatty:[10]
"With leadership goes power. Wise leadership uses power in the best interest of the enterprise and the groups related to it. In speaking of this power, Tead has said: 'Power comes by virtue of what we deeply are and do, and every great leader is a silent but eloquent witness to the fact that his power derives from his devotion, his loyalty, and his helpfulness to his followers in a common and important cause'."
"However, some who have leadership power abuse it. They use it to instill fear in their subordinates and to use them for their selfish interests. They seize power rather than earn it, or they acquire power as a result of appointment, a typical situation in industry. The power of the leader is an essential element in coordinating the efforts of the diversified people that make up the industrial enterprise. With the power, however, goes great responsibility, and the leader should be certain that he uses it in the best interests of all concerned. In the words of Jesus Christ, 'And whosoever will be chief among you, let him be your servant'."

LEGITIMACY OF MANAGERIAL POSITIONS

IN THE *Saturday Review*, dated January 18, 1958, R. J. Cordiner,[11] president of the General Electric Company, made the following statements:

"There was a time when the manager felt that his decisions had little influence on the nation's economic and military strength. Today, in many companies, decisions are made with a conscious reckoning of the company's responsibilities to the national defense and local, or even national, business conditions.
"There was a time when the manager felt that if his shareowners were happy and if his customers were not going over to his competitors, he was satisfying his managerial responsibilities. Today, the manager knows that continuing usefulness and profitability depend on a much wider spectrum of relationships involving not only customers and shareowners, but employees, other businesses, other institutions and the society as a whole.
"All this is to say that a new dimension has been added to business leadership: the social dimension."

The social legitimacy of a business enterprise derives from the recognition of opportunities and obligations inherent in performance as a socially valuable "corporate citizen"—the recognition by its leaders of this "social dimension." In our company, this is brought to fruition through the conscious effort of managers to make decisions in the balanced best interest of all who contribute to, and all who benefit from, the activities of the company including society as a whole. This is not easy. It involves weighing and deciding for each time and circumstance the best balance among contending, and often conflicting, forces and interests. But bringing to bear the greatest possible knowledge and wisdom coupled with integrity of purpose in making such decisions endows the effort with legitimacy. This last statement is based upon the acceptance of the beliefs expressed at the beginning of this paper, that the people concerned will voluntarily support such efforts.

A MANAGER'S RELATIONSHIPS WITH PEOPLE

HOW A MANAGER uses the power inherent in his position depends largely upon how he thinks about himself, his position in society and in the business enterprise, and how he thinks about his relationship with the man to whom he reports and with the people who report to him.

Several years ago Larry Appley,[12] president of the American Management Association, asked a group of executives about how managers' attitudes toward people have been changing in recent decades. Fig. 1 was made from his findings.

Skipping the first step of "slavery," which cannot exist in a democratic, free market, incentive enterprise, private ownership, society, let me ask myself if I am a manager, how much of the idea of servitude still remains in my way of managing. Do I habitually issue orders and expect unthinking, servile obedience? How do I react when I am the recipient of such an order and am expected to obey accordingly? Slavery and servitude depend upon command, force, and coercion. How can I avoid being treated as a servant myself and how can I manage the work of my component so as to avoid treating others that way?

The next step is "paternalism." This is a tricky step because it assumes that I, in my wisdom, know what is best for Jim and make decisions which affect him, assumedly, in his own best interest. Thus, my attitude

toward him is like a parent's attitude toward a child. I prevent him, for his own good, from taking risks and making mistakes on his own as though he were not yet an adult and, therefore, not yet ready to take his own risks, live with his own decisions, make his own mistakes, and profit from his own experience.

I said this was tricky because individuals over 21 years of age still have widely differing degrees of wisdom, mental, moral, and emotional maturity. A parent will give more and more responsibility to a child to help him grow up by learning from his own experience. At the same time, he will attempt to prevent him from taking actions which will be lethal or seriously damaging to others around him. Likewise, a manager, through the process of delegation, helps a man grow by giving him a job

A Professional Manager Leads rather than commands

Fig. 1

and leaving him alone to do it. The man can thus learn by doing, by being fully responsible and accountable for the results of his own deliberate choices, by profiting from his own mistakes. Reserved authorities not only are necessary to preserve and build company unity but also are in some degree reservations to prevent actions which will be lethal or even seriously damaging to the business, the individual, or his associates. In this sense, reserved authorities are paternalistic and the degree of reservation is determined by the manager's opinion of the maturity of the individual man. In the relationship between each man and his manager, the aim is to make delegation as complete as possible, to make as few limits, conditions, restrictions, or reservations as possible and still preserve over-all company unity and best interest.

The most frequently mentioned aid to personal growth is when a man is given an assignment and his manager sets high standards for performance and results, but leaves him free to work the job out himself, treating him like a responsible adult, not like a child.

Now for the "participation" step in this scale of relationships between people. Deliberately creating opportunities for participation in some degree, by some people, is ages old and a proved approach in managerial behavior. But we have not yet learned how to provide for appropriate participation in all aspects of managerial consideration in advance of decision making by all who will be affected by such decisions and by all who will be involved in carrying out such decisions. This is a desired objective in managerial behavior for several reasons:

1. If those concerned have been consulted, their contributions integrated, and their differences reconciled: (a) the decision will be better (i.e., it is more likely to be in over-all best interest; (b) the decision will be accepted better by all concerned even if some had previously held conflicting views (this is true because of the realization that the person accountable must make decisions in accordance with the requirements of his position and that encouragement of individuality and complete unanimity of opinion are incompatible ideas); and (c) the decision will be carried out better and faster (those concerned will know the extent of previous consideration and the reasons and judgment factors which led to the decision).
2. Participation in assessing component situations and planning activities and strategies in appropriate degree at each organizational level is a powerful learning mechanism, aiding each participant to broaden his viewpoint, increase his knowledge of his business, and improve his judgment.
3. Participation in component situation considerations leads to more voluntary teamwork and concerted action toward agreed upon component goals and less necessity for detailed instructions by the manager. It is a necessary antecedent and corollary to decentralization of decision making as an attitude of mind not just down to me but to every worker in appropriate degree.

The foregoing statements are generalizations.

The word "appropriate" applies throughout and is a loose word—an escape word—a judgment word. When thinking about any particular subject for discussion, and any particular person as a possible participant in discussion, appropriateness may be anywhere from 100% to 0%, from necessary and essential, to unnecessary, uneconomic, and unwise.

In planning for participation by himself and by others in any particular discussion, a manager must consider (1) to what degree is the individual likely to contribute; (2) to what degree can the individual's opinion and knowledge affect the result; (3) to what degree will the individual's work and attitude be affected by the result; and (4) to what degree is consideration appropriate to the individual's level of competence and his position in the organization structure.

It is certainly true that everyone cannot be in on everything. This is foolishness. The key words are appropriateness, over-all economy, essentiality, and expected results.

Next, for the step of "trusteeship." This has to do

with the thought that entrusted to the care and stewardship of each of us is a heritage of accumulated knowledge and accumulated physical capital. The written word is everyone's resource, special lore is the personal possession of some, the right to use accumulated physical capital is the result of family inheritance, personal acquisition, or temporary allocation by position in social organizations.

The "managerial attitude" is the feeling of responsibility to use such resources productively and economically so that their value is enhanced and not depleted; so that I, as a trustee, and as a result of my stewardship, pass on more, not less, than I receive. This is an attempt at a conscious expression of one of the underlying verities of human progress. This is "profit" in its broadest sense. This could be consciously recognized motivation for each individual's personal and business behavior.

The top step on this chart is "statesmanship" and it has been included not so much to indicate that I know what it means, but rather to indicate that there are and will be further steps in our progress in social relationships.

All of the foregoing has been said about relationships between people because each of us has deliberately chosen to work in his particular business enterprise. How I behave toward others depends upon my own self-concept, upon how I think about others who are associated with me, and how I expect others to think of and behave toward me. All of these things need to be in the conscious foundation from which a manager builds his plans for his own actions.

MANAGING VS MANIPULATION

THIS BRINGS US to the key point of this article and the reason for all the foregoing build-up of ideas. In our free society, as it is evolving, we are fast approaching the day when managers of "business enterprise" can no longer think and act as though we were on the bottom steps in the evolutionary progress of relationships between people. Managers can no longer rely principally on coercion, fear, and force to get "co-operation" and act like masters who expect servile unthinking obedience from those "whom they command" and to whom they "issue orders." Neither can they succeed through deception or cajolery or by sugar-coating their orders through a so-called "human relations" approach.

Furthermore, professional managers in large business enterprises cannot think of themselves as being like entrepreneur owners of the past. Because his own personal capital was at risk, the entrepreneur characteristically ran his business as a one-man show. He made all major and often many minor decisions and quite thoroughly directed the work of those whom he hired to help him.

There is a much larger concept wrapped up in the evolving profession of managing. It is quite possible that we have not yet envisioned the full sweep or the enormous potential for furthering human progress of this new kind of professional work but there are a few complementary ideas which stand out clearly:

1. It builds upon freedom in the market place and the assumption of the inherent rights of individuals to own, buy and sell property.
2. It assumes the dignity and worth of individuals, encourages individual growth, and rewards innovation and the exercise of initiative.
3. At the same time, it aims at providing working conditions and business climate so that individuals will voluntarily put forth their best efforts in concerted action to achieve optimum benefit for the individual, for his business team, and for society as a whole.
4. It recognizes that social evolution has reached the point where, in the long run, an individual can benefit himself most as he contributes most to increasing the productivity of all, not by taking away from someone else; by increasing total wealth, not just by redistributing present wealth.
5. Exercising social power through the making of managerial decisions is essential to achieve concerted action in complex business enterprises and is also essential to mass production and mass distribution upon which our "economy of plenty" is based.
6. The legitimacy of managerial decision making depends upon the making of such decisions in the balanced best interest of all who contribute to and benefit from the purposeful work of the enterprise.
7. "Managing" has a positive, beneficial, social connotation when to the best of his ability a manager makes decisions in the best interest of all concerned. Contrariwise, "manipulation" has a negative, detrimental, social connotation when an individual wields power of position to advance his own selfish interest at the expense of others, however skillfully his motives and even deceptions may be rationalized or camouflaged. The differences between these two opposing characterizations lie not so much in observable acts, as in the power holder's personal objectives, his personal ethical and moral code, and the way he thinks about the relationships between himself and others.

The manipulative approach has been all too common in the past. We are just beginning to see how a professional manager can provide leadership through making decisions concerning objectives, policies, plans, budgets, and schedules for his component, and develop the working climate in his component so that each individual has his unique set of responsibilities and his appropriate decision making power. Glimpses of what this kind of managing can mean have been described in references already given.[1-6, 11, 12] This total concept appears to present a much more hopeful goal toward which to work than either "democratic," "bottom-up" management or "benevolent autocracy" which were the two extreme alternatives discussed by McMurry.[13] He advocates the latter because, as he states, "while it is neither idealistic nor inspiring, (it) is practical . . . where it has been tried, it works." This is the voice of experience looking backward. Shouldn't we ask ourselves the question: Will it continue "to work" so well as our society

advances up the scale in "relationships between people" depicted in Fig. 1?

In describing the "manager of tomorrow" Peter Drucker[14] states:

> "The more successfully tomorrow's manager does his work, the greater will be the integrity required of him. For under the new technology the impact on the business of his decisions, their time-span and their risks, will be so serious as to require that he put the common good of the enterprise above his own self-interest. Their impact on the people in the enterprise will be so decisive as to demand that the manager put genuine principles above expediency.
>
> "And their impact on the economy will be so far reaching that society itself will hold the manager accountable. Indeed, the new tasks demand that the manager of tomorrow root every action and decision in the bedrock of principles, that he lead not only through knowledge, competence and skill but through vision, courage, responsibility and integrity.
>
> "No matter what a man's general education or his adult education for management, what will be decisive above all, in the future even more than in the past, is neither education nor skill; it is integrity of character."

E. Wight Bakke[15] of Yale sums up his thinking in this area as follows:

> "If we would match our economic strength with that of any totalitarian system, we must find the new technique. We must find a way to use not a small part but a larger part of the whole person, a way to elicit and inspire his energy and skill and creative ability in production, because in expending that energy he expresses his whole self. We must find a way to reduce the need for authoritarian co-ordination, possibly by putting more tasks and more important tasks, into the function of one man, so that larger area of activity of our economic organizations is self-co-ordinating.
>
> "We must aid men to acquire a concern and responsibility for the effectiveness and productivity of the whole organization, by giving them the opportunity to participate in taking responsibility for a larger part of the organization's activities than those narrow atomized tasks to which they are now assigned.
>
> "Don't misunderstand me, I'm not talking about turning the factories over to the workers. I'm not talking about the German system of co-determination. But I am talking about a serious attempt on the part of management in collaboration with their junior executives, their foremen, their workers and their union representatives to work out new organizational methods for modifying the past direction of scientific management: enlarging functions not narrowing them; combining, planning and doing; not separating them; decentralizing authority and responsibility, not centralizing them; giving men more to do, not less, more that is challenging and significant; utilizing the great stimulus to individual effort that can come from the group acceptance and support and solidarity, not trying to break it up by setting man against man in a competition from which only a limited few will gain. I'm not talking about being benevolent and kind to workers by giving them something out of managerial generosity, but about opening up for them the chance more fully to utilize their total capacities and express more of their personalities through their functions, and thus to earn what they get. And I'm not just talking about workers. I'm talking about foremen, junior executives, and managing executives as well.
>
> "I have put these answers in uncompromising form not to settle the issue, but to raise it. There are some who think this distinctive goal and objective of our Western society that I referred to has outlived its usefulness, that it is no longer a sure and certain guide, that it no longer shows us the direction in which we should move. I think these people are wrong, and I know many of you think they are wrong. We have had our countries tossed about like a ship at sea by political and economic waves and winds that have sometimes caused us to lose our sense of direction. But I am still convinced that maximum development of all our people as individuals, and that organizing both our political life and our economic enterprise so that we make full use of all our people is the objective by reference to which we should chart our course."

REFERENCES

1. Problems of Management in a Large Decentralized Organization, R. J. Cordiner. General Management Series No. 159, American Management Association, New York, N. Y. June 19-20, 1952, pp. 2, 7, 16.

2. General Electric's Philosophy and Approach for Manager Development, H. F. Smiddy. American Management Association, New York, N. Y. (reprinted from General Management Series No. 174), 1955.

3. New Frontiers for Professional Managers, R. J. Cordiner. Graduate School of Business, Columbia University, McKinsey Foundation Lecture Series, McGraw-Hill Book Company, Inc., New York, N. Y., 1956.

4. Dynamic Administration (book), M. P. Follett. (Collected papers, edited by Metcalf & Urwick). Harper & Brothers, New York, N. Y., 1940.

5. Bedrock Foundations for Manager Development, H. H. Race. *Electrical Engineering*, June 1956.

6. A Manager's Professional Attitude, H. H. Race. *Electrical Engineering*, May 1957.

7. The Book of Unusual Quotations (book), Rudolf Flesch. Harper & Brothers, 1957.

8. Power and Community (book), Robert Strausz-Hupe. Frederick A. Praeger, New York, N. Y., 1956.

9. A Study of Power (book), H. D. Lasswell, C. E. Merriam, T. V. Smith. The Free Press, Glencoe, Ill. 1950.

10. Principles of Industrial Management (book), L. P. Alford, H. R. Beatty. The Ronald Press Co., New York, N. Y. 1951.

11. New Dimension in Business Leadership. R. J. Cordiner, *Saturday Review*, New York, N. Y., Jan. 18, 1958.

12. Management in Action. L. A. Appley, American Management Association, New York, N. Y. p. 20.

13. The Case for Benevolent Autocracy, R. N. McMurry. *Harvard Business Review*, Cambridge, Mass., Jan.-Feb. 1958, p. 82.

14. The Practice of Management (book), Peter Drucker. Harper & Brothers, New York, N. Y., 1954.

15. The Horizons of Human Behavior, E. W. Bakke. Cornell College Bulletin, Mt. Vernon, Iowa, July 27, 1955.

New Developments in Light Sources and Optical Systems for Roadway Lighting

E. B. KARNS

Substandard street lighting covers 90% of our streets and 20-year old developments are labeled "news." Recent developments and techniques provide more light per dollar and should be adopted to avoid the risk of outmoded equipment becoming a liability.

THIS SUBJECT is so broad it is difficult to know where to start, especially when an estimated 90% of street mileage in the United States has substandard lighting. Developments discussed are only some of the highlights of the past 10 years.

First, let us take a look at developments in the light sources themselves. Fig. 1 shows the historical developments in efficiency of these light sources and some predictions for the future.

Mercury lamps are today available in a variety of sizes and colors—from a 100 watt to 1,000 watts for street lighting.

In this lamp you have a source 2 to 3 times as efficient as the incandescent lamp, and with a lamp life 3 to 10 times as long as filament lamps.

One should no longer think of the mercury lamp as a blue-green color, because we now have in this lamp phosphors that provide such lamps as the "silver white" or "colortone," "Hi-output" white with about 5% red added, the "color-corrected" or "colortone" standard white with about 9 to 10% red added. The newest is the "colortone" deluxe white lamp; this lamp has still more red, is a super color corrected lamp for use where you want to have the best color rendition for a mercury type light source. Also, the mercury lamp is available in "amber" and in "yellow-amber" for marking hazardous locations.

There is a size for every size application in the efficient long life mercury lamp (Fig. 2): 100 watt, 3,500 lumens; 175 watt, 6,800 lumens; 250 watt, 11,000 lumens; 400 watt, 21,000 lumens; 700 watt, 36,500 lumens; and, 1,000 watt, 55,000 lumens; plus a number of variations depending on the color. Colortone "Hi-output" white type furnishes about 10% more light for the same wattage.

Fig. 3 shows the latest development in a mercury luminaire. It is designed for the 100 watt, 3,500 lumen; or the 175 watt, 6,800 lumen; or the 250 watt, 11,000 lumen lamps.

Since lamps of this size would be used primarily on residential streets or relatively narrow streets, this unit is designed to give Illuminating Engineering Society–American Standards Association (IES–ASA) Type II distribution.

The optical system provides a Type II lateral spread with minimum toe-in, and with the angle of maximum vertical candlepower at 78°. This provides for best utilization and uniformity for long spacings usually found on residential streets. This allows spacing up to 8 or 10 times the mounting height, and still conforms

A special article recommended for publication by the AIEE Production and Application of Light Committee.

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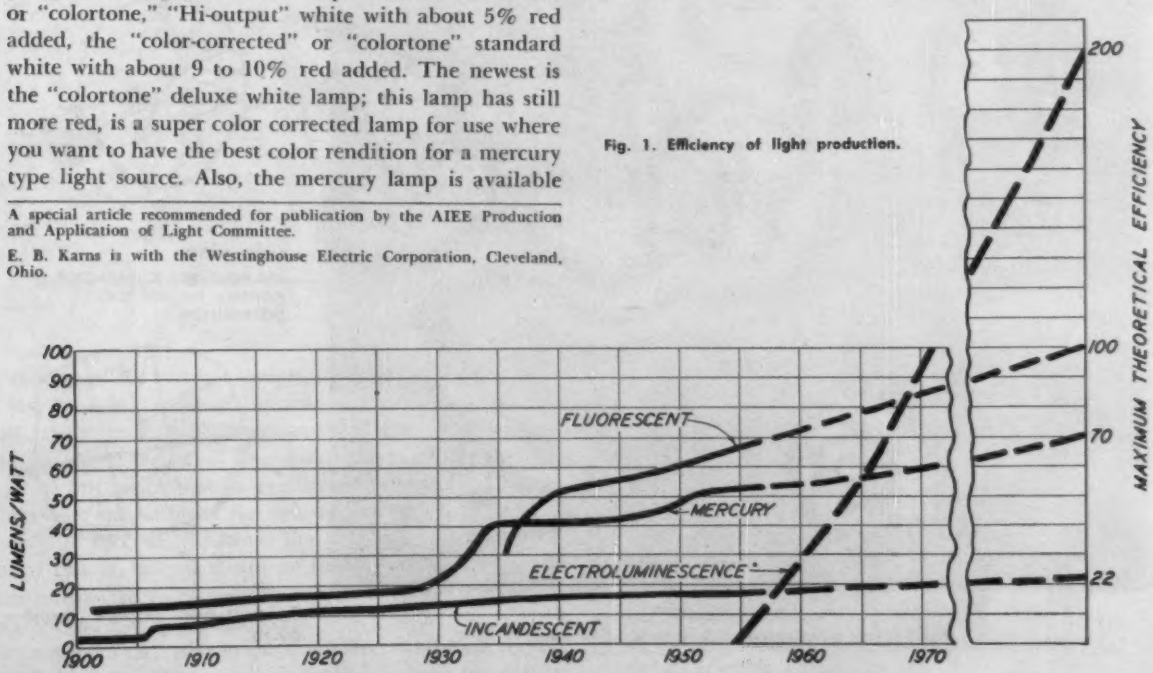


Fig. 1. Efficiency of light production.

to the IES–ASA Standards for uniformity on this class of street.

MODERN STREET LIGHT

THE MODERN STREET LIGHT employs two basic elements of optical control: (1) a main reflector, and (2) a refractor. Each must be scientifically designed to work together.

The light source is well up in the reflector. This is done for two reasons: (1) to shield the source brightness from normal line of sight, and (2) to allow redirecting of the light from the reflector to get minimum of light directed back through the source, and to provide as large a flash area as possible for the main beam. Beam candlepower is a product of the brightness of the source times the flash area of the reflector corrected by the reflectance efficiency of the reflector surface. Therefore, to get maximum main beam light flux one needs a high brightness source, a highly efficient reflector surface, and a large area of the reflector committed to the main beam.

Fig. 4 shows how this is done. The light from the reflector in the main beam is at 69°, whereas it is desired to have it at 78°. By the use of horizontal prisms in the refractor, the main beam is elevated up to 78°, whereas the light at angles lower than 69° is spread by prisms to reduce the amount of light directly under the unit.

Across the long axis of the optical system, the light is pushed out and across the street. The upper sections of the refractor at the curb and street sides is provided with depressing prisms to direct the light down to the street. This minimizes the amount of light that would otherwise go on the houses along the street. These are sometimes referred to as shading prisms.

With mercury lamps that give an average life of 7,000 hours or longer, the necessity of going to the unit for relamping more often than about once every 2 years has been eliminated, thus greatly reducing the cost of maintenance. But most street lighting luminaires have an opening where the lead wires enter the optical system and connect to the socket. This allows a certain amount of dust and dirt, even bugs, sometimes to enter the unit. This means going to the unit and cleaning it once or twice a year.

Fig. 5 shows a unit that has something new—a sealed optical system. The porcelain-clad socket is gasketed to

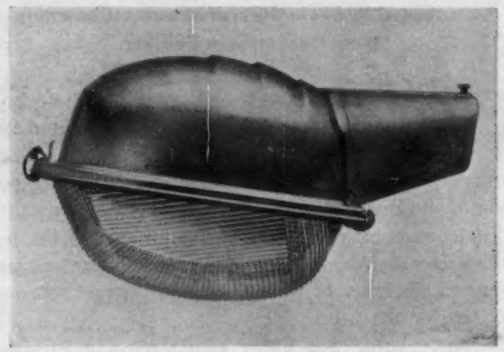


Fig. 3. Latest development in a mercury luminaire.

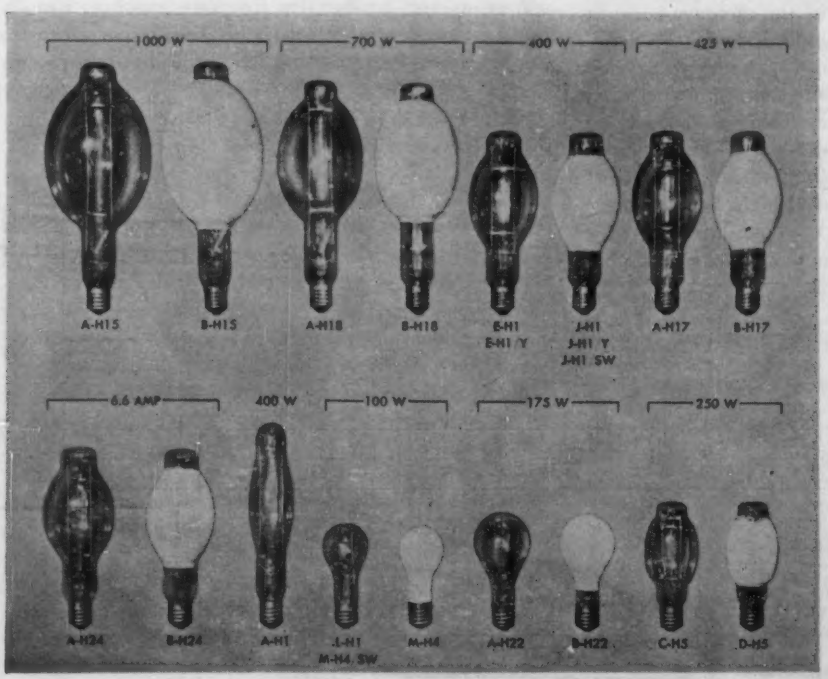
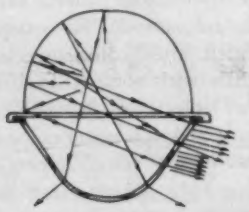


Fig. 2. Mercury lamps from 100 watts to 1,000 watts.

end view

THE REFLECTOR & REFRACTOR CONTROL THE VERTICAL DISTRIBUTION



side view

THE REFLECTOR & REFRACTOR CONTROL THE VERTICAL DISTRIBUTION

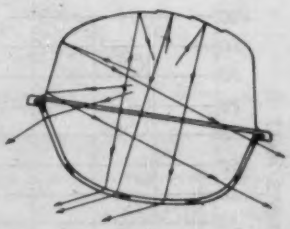


Fig. 4. Methods of light control—OV-10.

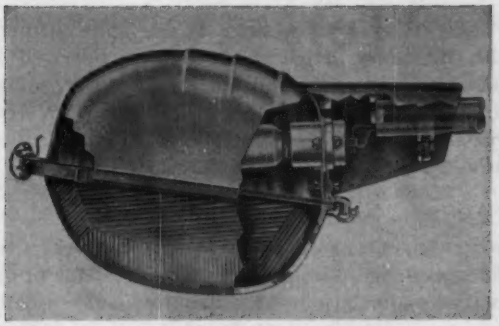


Fig. 5. A sealed optical system.

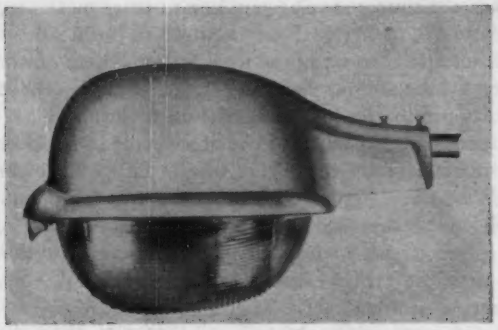


Fig. 6. The new mercury unit OV-35.

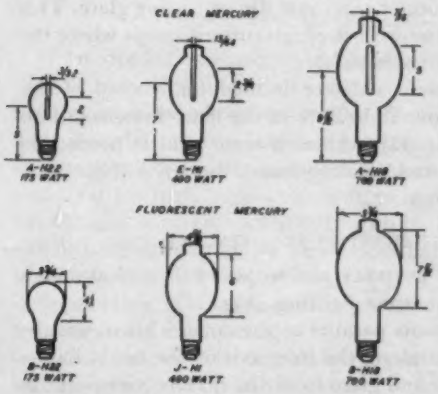


Fig. 7. Mercury lamps source size comparison for optical design.

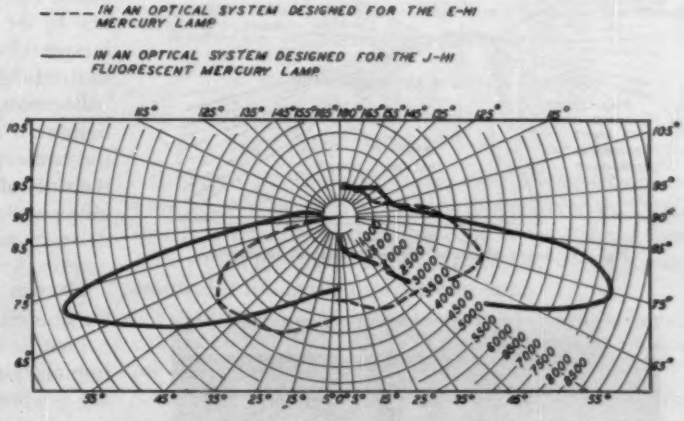

IN AN OPTICAL SYSTEM DESIGNED FOR THE E-H1 MERCURY LAMP
IN AN OPTICAL SYSTEM DESIGNED FOR THE J-H1 FLUORESCENT MERCURY LAMP

Fig. 8. Candle power distribution using J-H1 fluorescent mercury lamp.

phosphor coated lamps of either the 400 watt or the 700 watt size. With the developments in high temperature phosphors, the phosphor coated lamp is destined to become more efficient than the clear lamp.

To get best optical performance, an optical system must be designed around the physical size of the source (Fig. 7). In the case of phosphor coated or fluorescent mercury lamps, the source becomes the size of the outer bulb. So it becomes many times larger than the arc size in the clear lamp.

Fig. 8 shows the results in optical performance of the 400 watt *J-H1* lamp in an optical system designed for the *E-H1* clear lamp as compared to an optical system designed for the *J-H1* phosphor coated fluorescent mercury lamps.

Completing the group (Fig. 9) of mercury luminaires are the *OV-60* and *OV-20*. The *OV-60* is designed for the 1,000 watt or the 700 watt lamps. As these large sources would normally be used on wide streets, this unit provides a Type IV distribution.

The *OV-20* is the first optical system designed to operate the mercury lamp in a horizontal position, and has been available for over 10 years. It provides Type II or Type III with the clear lamp, and Type IV with the phosphor coated lamp.

the reflector. The wire connectors are made to terminals on the back of the socket outside the optical system. Then, the refractor seats direct to the lower edge of the reflector and is sealed off by a gasket, thus keeping the inside of the optical system free from dirt and dust and eliminating the necessity for cleaning for long intervals of time. In fact, with the long-life lamp and the sealed optical system, one need not go to the unit more frequently than 18 to 24 months on the average. This is a significant savings in labor cost.

The next to the latest in the new mercury units is the *OV-35* (Fig. 6). This unit is optically designed for the

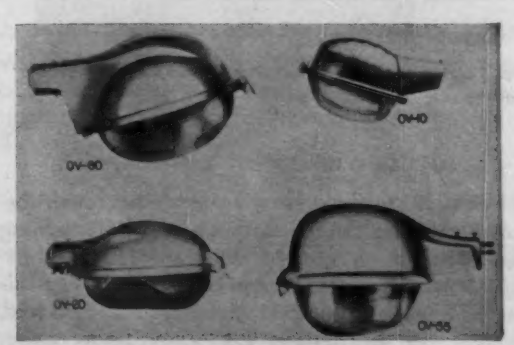


Fig. 9. Mercury luminaires.

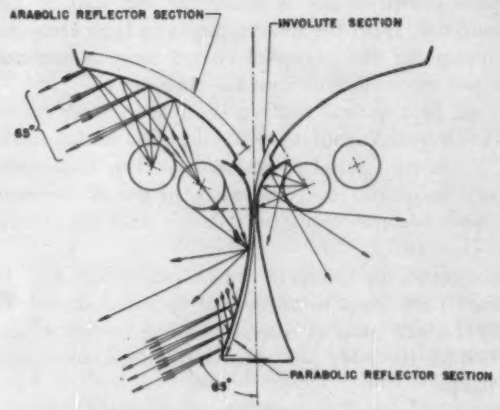


Fig. 10. Reflector ray pattern on type 4FSL-72 luminaire.

Fig. 11. A fluorescent luminaire with exposed light source.

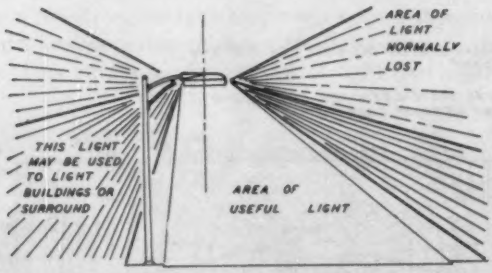


Fig. 12. Areas of useful light—fluorescent luminaire.

Fig. 13. A new concept in optical design for fluorescent street lighting.

TUBULAR FLUORESCENT LAMP UNITS

In the last three or four years we have seen the use of the tubular fluorescent lamp for street lighting applications.

For the most part, these lamps have been 1,000 milliampere, 6 feet long, in a *T-12* diameter tube. However, there are several sizes of these "LT" (Low Temperature) types of fluorescent lamps for outdoor use.

In addition to those operated at one ampere, there are the still newer "High Output" lamps operated at 1.5 amperes. In the *T-12* bulb size there is the Westinghouse "SHO" (Super High Output), Sylvania "VHO" (Very High Output), and the *T-17* bulb size General Electric "Power Groove."

THE LUMINAIRE

The long tubular fluorescent lamp presents a little different design problem. The luminaire, due to the relatively low lumen output per foot of lamp, usually has two or more lamps per luminaire. General practice is to mount two reflectors back to back with one or two or more lamps per reflector (Fig. 10).

Since the source is relatively low in brightness, large reflectors or "flash areas" are required to build up candlepower. (It is to be noted that, at best, these candlepower values are far below those of incandescent or mercury luminaires for the same lumen rating.)

Progress is being made to overcome some of the problems in fluorescent; the higher output lamps for example. With these higher current lamps, two lamp luminaires can be used and provide about as much light on the street as the 4-lamp 1,000-milliampere unit does. But with these high-current lamps, source brightness becomes a problem.

The fluorescent luminaires (Fig. 11) have exposed light sources with no shielding or diffusion in their clear plastic enclosures. The magnification of the lamp brightness by the reflector can cause discomforting glare. This is especially true with the high-current lamps where the source brightness is higher.

Because only a reflector is used for control of the light, only about 22 to 25% of the lamp lumens fall on the street (Fig. 12). Although some light is needed on the sidewalks and building fronts, there is still considerable wasted light.

NEWEST IN FLUORESCENT

Here is an entirely new concept in optical design for fluorescent street lighting (Fig. 13).

First, it mounts parallel to the curb. This means the line of sight is along the long axis of the lamp, reducing brightness and glare from the drivers' viewpoint to practically nothing.

The optical system for the first time, in fluorescent street lighting, employs prismatic control or a refracting lens. The reflector directs the light out and across the street, while the refractor directs the light laterally up and down the street (Fig. 14). This better control of the light results in an improvement in coefficient of utilization of about 50% over previous fluorescent units (Fig. 15). Although any of the tubular fluorescent lamps can be used, it is designed primarily for use with the high output lamps.

Another unique feature of this unit is the control of the light above the angle of maximum candlepower. The prism structure at the top section of the refractor performs a function of "shielding," or reducing greatly, the candlepower above about 70°. So that, as the driver

drives down the street, there is essentially no brightness in his line of vision.

We have heard a great deal about comfort in seeing. The greatest detriment to comfort is glare, and glare is scientifically described as disability veiling brightness.

If we refer to the early investigations made about 1939 by Reid and Chann, we find in their evaluation of street lighting a formula for disability veiling brightness.

Using this formula and calculating the accumulative veiling brightness for a total of eight luminaires which is necessary to assimilate a lighting system, we arrive at a system analysis as shown in Fig. 16.

This chart can be interpreted to indicate that the HUS (High Utilization Street Light) lighting system provides only one seventh the glare of a standard mercury lighting system, one ninth the glare of a conventional fluorescent system using the 1-ampere lamp and only one twelfth the glare of the fluorescent system using the 1.5-ampere lamp.

It is also interesting to note that the conventional mercury lighting system provides less glare than does either of the conventional fluorescent lighting systems.

We now have within our grasp comfortable roadway lighting.

Heat is a problem with fluorescent lamps. These outdoor lamps reach their peak efficiency at a 72 to 77° bulb wall temperature. In this unit, the ballast is mounted in the bracket outside the lamp housing, thus removing its heat from the lamps.

USE OF NEW MATERIALS

WITH THE FLUORESCENT UNIT, has come the introduction of some new materials into the field of outdoor lighting such as laminated molded fiberglas housings. This material has two inherent good qualities for this application: (1) it is impervious to corrosive conditions, and (2) it has high impact strength, to resist denting in handling, or from tree limbs falling on it. This material will be used more and more for outdoor lighting because of its indestructible properties.

By molding in reinforcements you can make such a housing structurally strong.

Basically these new materials have many good features and apparently no undesirable ones.

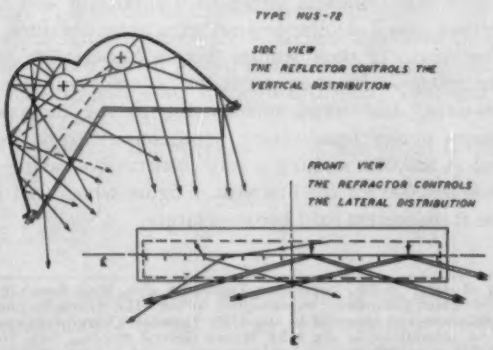


Fig. 14. Methods of light control using prismatic control or refracting lens.

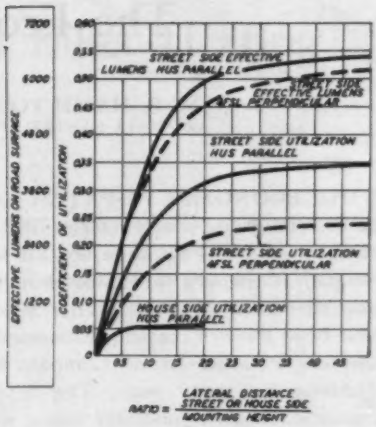

STREET SIDE EFFECTIVE LUMENS HUS PARALLEL
STREET SIDE EFFECTIVE LUMENS AFSL PERPENDICULAR
STREET SIDE UTILIZATION HUS PARALLEL
STREET SIDE UTILIZATION AFSL PERPENDICULAR
HOUSE SIDE UTILIZATION HOS PARALLEL
EFFECTIVE LUMENS ON ROAD SURFACE
COEFFICIENT OF UTILIZATION
RATIO = LATERAL DISTANCE STREET OR HOUSE SIDE / MOUNTING HEIGHT

Fig. 15. Utilization curve.

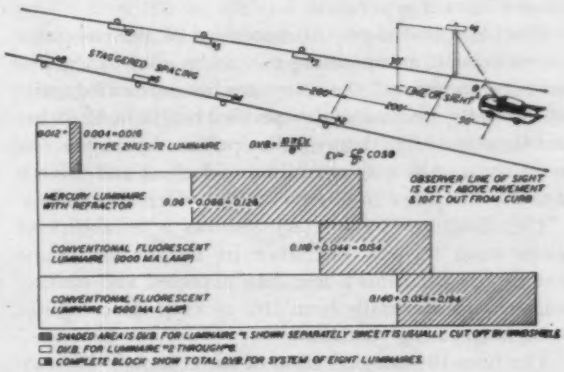

STAGGERED SPACING
LINE OF SIGHT
TYPE 2HUS-12 LUMINAIRE
OBSERVER LINE OF SIGHT IS 45 FT. ABOVE PAVEMENT & 10FT. OUT FROM CURB
MERCURY LUMINAIRE WITH REFRACTOR
CONVENTIONAL FLUORESCENT LUMINAIRE (1000 MA LAMP)
CONVENTIONAL FLUORESCENT LUMINAIRE (1500 MA LAMP)
SHADED AREA IS DI/B FOR LUMINAIRE #1 SHOWN SEPARATELY SINCE IT IS USUALLY CUT OFF BY WINDSHIELD
DI/B FOR LUMINAIRE #2 THROUGH #8
COMPLETE BLOCK SHOW TOTAL DI/B FOR SYSTEM OF EIGHT LUMINAIRES

Fig. 16. Disability veiling brightness comparison.

SUMMARY

IN THE LAST 10 TO 12 YEARS, most all developments have been in the field of gaseous discharge lamps. More specifically, mercury and fluorescent. *Why?* Because long since we seem to have reached the peak of efficiency, with reasonable life in the incandescent lamp.

These gaseous discharge sources offer much higher efficiency and longer life, making them more desirable for street lighting.

At present, the mercury is the most economical. However, with improvements in tubular fluorescent lamps, and improved optical systems that give better control of the light, we will find the gap between the cost of mercury and fluorescent closing. Some day, there probably will be only a slight difference. Fluorescent is in its infancy—and many changes will be seen in the next few years.

CONCLUSION

THOSE CHARGED with the responsibility of street lighting should take advantage of these more recent developments and techniques. Their adoption and use will enable lighting engineers to provide more light per dollar than can possibly be done with older outmoded equipment. Obsolete and outmoded equipment should be scrapped before it becomes a liability.

The Economic Dispatch Computer

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THE ECONOMIC DISPATCH COMPUTER has been in service since February 1957 at Charleroi, Pa., central dispatching headquarters for West Penn Power Company. Generator load dispatching for the integrated properties of West Penn Electric System, consisting of West Penn Power Company, Monongahela Power Company and Potomac Edison Company has been done at Charleroi for many years. The development of the economic dispatch computer was a joint development between the engineers of West Penn and the Westinghouse Electric Corporation.

The basic philosophy in the design of the computer was to make it an operating tool to be used by the dispatchers. In general, the computer has performed quite satisfactorily. Because of the specified height of 40 inches and the slope of 42 degrees, the operator has easy access to all servo units with a minimum of effort and can see over the computer to observe meter information easily.

The computer service factor shows a reliability of better than 99 per cent since its installation. Tube trouble has been much less than expected and routine maintenance has easily been able to keep the computer in high operating condition.

The hour-to-hour operation of the economic dispatch computer involves a knowledge of the generating units that are operating, the unit maximum and minimum value, the cost curve at which the unit is operating, and the fuel cost multipliers. Stations that are on regulation are set as fixed stations at the center of their regulating band. The total system load is set into the power meter and the servos automatically comes to rest at the most economic generation for the lowest delivered power cost. This information is then transmitted to the power stations by telephone and the necessary changes in station output are made.

The dispatcher has before him telemetered values of the load being carried at each station and can see that the changes are made as requested. The load regulating stations are set to hold the tie line on schedule. The schedule is affected by the purchase or sale of power and frequency bias. As tie lines get off schedule as the result of system load change, a load pick-up or drop is automatically taken care of by the regulating stations within their band limits. When these stations get beyond their band settings, the economic dispatch computer is called upon to indicate where load should be picked up or dropped in order to cause the regulation stations to return again to the center of their respective regulating bands.

The West Penn Electric System is so situated that economy power transactions with nonaffiliated interconnected companies are continually being made. One important use of the computer is to determine the value or worth of power at the tie lines. If the worth of power at the tie line is 0.4 mill or more different between systems, the dispatcher can agree to buy or sell economy power on a split-saving basis. These negotiations, greatly facilitated by the computer, take place at about 15 minutes before each hour on the expected load for the forthcoming hour. The power is not considered firm and can be canceled at any time. Therefore, spinning is carried against it.

Provision was made on the computer for certain future system changes foreseen at the time the computer was constructed. When space has been used up, it has been proposed to add another 30-inch section to the computer, containing 16 servos. Provision for this expansion has been made in the room, and additional telemetering space has been provided on the switchboard. An additional piece of equipment is now under consideration and will simplify the dispatchers' economy power transactions. This device will provide him with the average cost of any block of power so that the negotiations with the nonaffiliated company can be carried on very easily.

A detailed study was made of the savings resulting from dispatching with the computer as against the former method of equal bus-bar costs. An actual weekday, a Saturday, and a Sunday were selected from the four seasons of the year. These were selected as being typical of these periods. Power was dispatched by the dispatchers on the former method of equal bus-bar costs. These daily load curves together with their dispatch were then set into the IBM (International Business Machines Corporation) *704* and the system losses obtained using the loss formula now in the computer. The losses were subtracted from the input generation, thus giving the received load. The received load was then properly dispatched by the *704* on the basis of lowest delivered power cost in the same manner as the economic dispatch computer would have accomplished this operation. Cost per hour was obtained under each condition and the difference noted. Dollar savings were then obtained.

The results of these studies show a conservative saving of $30,000 with the present load control equipment limitations. Additional savings due to the increased economy power transactions were conservatively estimated at $20,000, making a very conservative saving of at least $50,000 for the first year, a figure which will increase if the system load becomes larger.

Digest of paper 58-207, "Operating Experience with West Penn's Economic Dispatch Computer," recommended by the AIEE System Engineering Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958.

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Heat Flow Problems in Induction Billet Heating

R. M. BAKER
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INDUCTION HEATING is widely employed today in heating billets for forging and extrusion. Starting with the solutions of certain classical heat flow problems, equations and procedures are developed for analyzing and planning induction billet heating cycles.

A typical job requires that billets arrive at the press at a specified rate, heated to a specified average temperature, and with the temperature differential between surface and center not greater than a certain specified amount. Although induction heating generates heat below the surface of the billet, heating near the surface predominates. It is, therefore, necessary to limit the rate of heating to allow for temperature equalization by conduction.

The methods covered by this article are illustrated by considering the somewhat idealized heating cycle of Fig. 1. It is assumed that the billet is heated by constant power input at the surface. The surface temperature increases at first faster than the center temperature, but after time t_1, the center temperature catches up. Thereafter, all temperatures in the billet increase at the same constant rate. The time t_1 is given by

$$t_1 = \frac{\gamma c a^2}{4 k} \text{ seconds} \quad (1)$$

where

γ = density, grams per cubic centimeter
c = specific heat, calories per gram per degree C
a = billet radius, centimeters
k = thermal conductivity, calories per second per centimeter per degree C

When heating is terminated after time t_2, the temperature differential between surface and center is

$$V_s - V_c = \frac{P_0 a}{2 k} \text{ degrees C} \quad (2)$$

where P_0 is the surface power density in calories per second per square centimeter. Note that this is the drop in temperature which would result from a power density P_0 flowing uniformly through a distance equal to one half the radius.

Considering the heat capacity of the billet, it can be shown that

$$t_2 = \frac{\gamma c a V_a}{2 P_0} \quad (3)$$

where V_a is the average temperature of the billet at the end of heating or the temperature to which the billet will equalize if losses are negligible during equalization.

Economic use of equipment dictates the acceptance of the largest possible differential at the end of heating consistent with metallurgical limitations. Billet temperature is allowed to equalize, usually outside the coil, to some low differential acceptable at the press. The time required for the differential to be reduced to 10% of its initial value is

$$t_3 = \frac{0.154 \gamma c a^2}{k} \text{ seconds} \quad (4)$$

When one agrees on an acceptable value of temperature differential at the end of heating, the allowable power density P_0 is determined by equation 2. Substituting this value of P_0 in equation 3 determines heating time t_2. The equalizing time t_3 calculated from equation 4 will usually be more than adequate to produce the low temperature differential required at the press. With t_2 determined, one knows the number of heated billets per hour obtainable from a single coil or the length of coil required for a given production when billets are progressively fed through the coil. The total thermal power required is

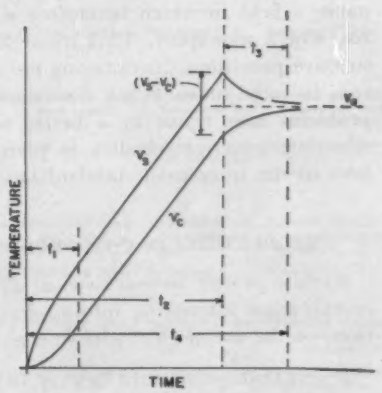

Fig. 1. Typical billet heating cycle.

$$P_T = M c V_a \text{ calories per second} \quad (5)$$

where M is the mass rate of production in grams per second. Since thermal losses have been neglected in this simplified analysis, the coil input required is simply P_T divided by coil efficiency. Total power in kilowatts is equal to the total power in calories per second divided by 238.

Digest of paper 58-202, "Classical Heat Flow Problems Applied to Induction Billet Heating," recommended by the AIEE Electric Heating Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Applications and Industry*, May 1958, pp. 106-12.

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National and State Electrical Requirements for A-C Mining

C. L. BROWN

A discussion of the lack of uniformity of state mining laws which have hampered operations of interstate coal-mining companies. This situation has been aggravated by the trend toward wider use of a-c mining equipment against which some state laws are particularly restrictive.

MANUFACTURERS, engineers, and coal-mining companies operating across state lines encounter numerous problems because of lack of uniformity in mining laws of various states. Variations in laws regarding use of electricity provide an example.*

There is now a definite trend toward wider use of alternating current (a-c) for operating mining equipment, a field in which heretofore direct current (d-c) has had a monopoly. This trend has emphasized restrictive provisions discouraging use of alternating current in some states. Frank discussion of some of these problems may result in a better understanding and stimulate governing bodies to plan revision of their laws in the interest of standardization.

REGULATIONS IN COAL-PRODUCING STATES

REVIEW OF THE MINING LAWS of 22 states and Alaska reveals some interesting information regarding regulations on the use of electricity in coal mines.

Direct-Voltage Circuits. Laws of 10 states do not place a maximum on direct voltage. Four states specify a maximum of 275 volts; three, 300 volts; one, 550 volts; one, 600 volts, and two, 650 volts. Regulations in Alaska limit bare d-c conductors to 300 volts and insulated conductors to 500 volts.

High-Voltage Circuits. Little consideration has been given to specifications for high voltage in most state laws. One state permits 5,000 volts, phase to ground, and another requires approval for installation of voltage above 2,200. Other states place no limit on high-voltage alternating current.

Low-Voltage Circuits. Eleven states and Alaska have no restrictions on the maximum utilization voltage for operation of equipment in coal mines. Maximum utilization voltage is 240 in one state and 260 in another, except by special permission. Four states recognize 440 volts nominal, and five states sanction 550 to 650 volts.

High-Voltage Cable. No restriction is placed on the type of high-voltage cable that may be installed in coal mines of 8 states. Cables insulated for 150% voltage, armored or installed in conduit, are required by one state and type *SH-D* or equivalent is required by two. Metallic armor or conduit is specified in four other states. Regulations of six states require high-voltage cables to be adequate for the service intended. Liberal interpretation of the laws of several states might permit the use of nonmetallic sheathed cable, and the laws of two states refer to lead-sheathed cable.

Installation of High-Voltage Cable. Five states have no restriction on location and method of installing high-voltage cables. One state requires armored cables to be installed in intake air, buried not less than 12 inches or installed in conduit. Other states provide a variety of choices, with emphasis on protection against mechanical damage.

Splicing and Cable Extensions. Requirements for cable splicing are specified in five states.

Transformers. Ten states require air-cooled or nonflammable liquid insulated transformers for new installations; one of these also recognizes inert gas-filled types. Another state prohibits using more than 20 gallons of flammable oil in transformers.

Overload and Short-Circuit Protection. Overload and short-circuit protection for power circuits is required in 16 states and Alaska. In each instance, details of requirements are meager.

Transformer Stations. Enclosures for transformers installed in coal mines are not regulated in five states. Specific approval from the department of mines is required for installations in two states. Fire hazard from ruptured transformer tanks containing flammable oil is recognized in the laws of six states. Where transformers are insulated with nonflammable materials, seven states relax requirements for enclosures.

Transformer Connections. High-voltage and low-voltage connections for transformers are specified in one state.

SUMMARY OF REQUIREMENTS OF STATE LAWS

THE WIDE DIFFERENCE in maximum voltages specified for operation of mining equipment in the various states

Essentially full text of a conference paper presented at the AIEE East Central District Meeting, Huntington, W. Va., May 13-15, 1958, at a session sponsored by the AIEE Mining and Metal Industry Committee.

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*References to state laws in this paper are based on interpretations by the author and may not coincide with interpretations by the various governing bodies.

Table 1. Some State Regulations on Electrical Installations

State	Maximum a-c High Voltage	Maximum a-c Low Voltage	Cable Required for High Voltage Installations	Location and Installation, High Voltage Cable	Splicing or Joining Sections of High Voltage Cable	Fault Protection		Type Transformer	Transformer Station Enclosure
						High Voltage	Low Voltage		
Alabama	Not stated	Not stated	Not stated	Supported on insulators	Continuity of armor and conduit to be maintained	Automatic cutouts	Overload devices	Air-cooled or nonflammable liquid	Fireproof enclosure for oil-filled; door sills
Arkansas	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Colorado	Not stated	600	Lead used in dry locations only; reference made to armored	Approved manner, supported at 5-foot intervals	Not stated	Fuses or circuit breakers	Fuses or circuit breakers	Air-cooled or nonflammable liquid	Fireproof or fire-resistant means to confine oil
Illinois	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Fireproof construction
Indiana	Not stated	650 phase to ground	Not stated	Regularly inspected passageways; protected against damage	Strength, insulated adequately, armor continuous	Automatic devices	Automatic devices	Air-cooled, nonflammable liquid, or inert gas	Fireproof underground structures
Iowa	Not stated	Not stated	Armored or insulated above 100 volts	Safely located	Not stated	Not stated	Not stated	Not stated	Not stated
Kansas	No regulations on electricity		—	—	—	—	—	—	—
Kentucky	Not stated	440	Shielded	Buried or protected against contact; installed in intake air	Not stated	Overload protection	Overload protection	Not stated	Barrier for oil-filled
Maryland	Not stated	Not stated	Adequate for service intended	Permanent—guarded against mechanical damage	Not stated	Fuses or circuit breakers	Fuses or circuit breakers	Air-cooled or nonflammable liquid	Fireproof construction
Missouri	No regulations on electricity		—	—	—	—	—	—	—
Montana	Not stated	Not stated	Adequate for service intended	Permanent—guarded against mechanical damage	Not stated	Short circuit, overload	Short circuit, overload	Air-cooled or nonflammable liquid for new installations	Fireproof construction
New Mexico	Not stated	550	Metallic sheath or armor	Armored type permitted in return airways	Not stated	Overload and short circuit	Overload and short circuit	Not stated	Fireproof room
North Dakota	No regulations on electricity		—	—	—	—	—	—	—
Ohio	5,000 phase to ground	260 except by approval	Insulated for 150 percent voltage, installed in conduit, or armored	In or on bottom or suspended	Not stated	Circuit breakers and fuses	Circuit breakers and fuses	Not stated	Approval of Dept.
Oklahoma	Not stated	Not stated	Adequate for service intended	Permanently guarded against mechanical damage	Not stated	Overload and short circuit	Overload and short circuit	Air-cooled or nonflammable liquid	Fireproof unless air-cooled or nonflammable liquid
Pennsylvania	Not stated	650	Metallic armor or conduit, armor continuous	Intake other than haulage-ways, buried not less than 12 inches or conduit	Junction boxes or permanent splices	Oil breakers, fuses 25 kw or less	Fuses	Limit of 20 gallons flammable liquid	Suitable chamber intake air, 20 gallon oil limit
Tennessee	Not stated	Not stated	Adequate for service intended	Permanent guarded against mechanical damage	Not stated	Overload and short circuit	Overload and short circuit	Air-cooled or nonflammable liquid	Portable fireproof; door sills for flammable oil
Utah	Not stated	440	Adequate for service intended	Intake air	Mechanically and electrically efficient	Circuit breaker or fuse	Overload and short circuit	Not stated	Fireproof
Virginia	Not stated	480	Not stated	On insulators unless buried	Not stated	Overload and short circuit	Overload and short circuit	Air-cooled or nonflammable liquid	Fireproof housing unless of fireproof design
Washington	Not stated	600	Lead covered or armored, restricted by type installation	Insulators unless grounded armor; intake air in gassy mines	Electrically efficient, adequate insulation; metallic armor continuous	Overload and short circuit	Overload and short circuit	Not stated	Suitable chambers, in intake air
West Virginia	2,200 and above by approval only	440	Individual conductors shielded; shielding continuous and grounded	Intake air other than travelways unless buried 12 inches	Not stated	Overload and short circuit	Overload and short circuit	Air-cooled or nonflammable liquid for new installations	Flammable oil in fireproof structure
Wyoming	Not stated	240	Adequate for service intended	Permanently installed, guarded against mechanical injury	Not stated	Overload and short circuit	Overload and short circuit	Air-cooled or nonflammable liquid	Fireproof structure
Alaska	No limit on armored cable	Not stated	Armored, pick-proof cable	Not stated	Not stated	Overload and short circuit	Overload and short circuit	Not stated	Fireproof structure

reflects the need for greater uniformity in state mining laws. Introduction of continuous mining equipment has created serious power transmission problems in states limiting low-voltage circuits to 300 volts or less. Likewise, the trend to larger locomotives has increased power demand for haulage.

Minimum attention has been given to high-voltage power transmission. Some regulations in force appear to restrict efficient transmission of large quantities of power.

State laws generally have not kept pace with development of high-voltage cables and protective equipment. This is an obstacle to the introduction of alternating currrent in mines of at least one state. Lack of uniformity in requirements for installation and location of high-voltage circuits is not conducive to good engineering standardization.

Splicing and extensions in high-voltage cable have been given minimum attention.

Hazards of flammable oil-filled transformers are rec-

ognized in many state laws; however, the relative safety of improved types of transformers receives minimum consideration.

The safety advantages of modern systems available for protection against overload and short circuits are not emphasized in state regulations.

Although many state laws require fireproof construction for transformer stations, they lack specific details regarding ventilation to control smoke and gases in case of fire. Some states make no exception for housing transformers insulated with nonflammable materials. The Federal Coal Mine Safety Act does not include specific requirements for a-c mining.

PROBABLE CHANGES IN STATE LAWS

MUCH WOULD BE CONTRIBUTED to the efficiency of coal mining and associated industries if state laws were standardized to permit installation and use of modern electric equipment supported by good engineering techniques. Important among the changes needed are:

1. Standardization of maximum voltages to permit efficient operation of modern mining equipment.
2. Provision for use of latest developments in power cables.
3. More liberal restrictions on location and method of installing properly protected cables.
4. Standardization of cable sectionalization and splicing requirements.
5. Insulation specifications for air-cooled transformers and ventilation requirements for nonflammable oil-filled transformers.
6. Specific requirements for protection against faulted circuits.
7. Standardization of requirements for installation of transformer stations in coal mines.

An Accurate Analog Frequency Measuring Circuit

JONATHAN MITCHELL

An instrument has been developed which will automatically convert frequency into shaft position, with an accuracy of ±0.1% over a temperature range of −55 C to +55 C. Methods are shown for compensating for the imperfections of diodes as switches, thereby achieving a high degree of linearity and stability.

DURING THE COURSE of work on an electromechanical analog computer, it became necessary to convert frequencies of 2 to 20 kc into shaft rotations. The shaft rotation had to be proportional to frequency with a departure from linearity of less than ±0.1% of full scale. The circuit was required to operate over the temperature range of −55 C to +55 C.

A diode pump circuit,[1] which consists of a pair of diodes used as a switch to charge and discharge a capacitor alternately, was chosen for its simplicity and consequent reliability. Modifications to the basic circuit were necessary because of the imperfect operation of diodes used as a switch.

THE BASIC CIRCUIT

THE DIODE PUMP uses each cycle of input frequency to remove a fixed charge from a storage capacitor. The integral of these charges is a current proportional to frequency, which is balanced against a current derived from the tap of a linear potentiometer. Any current unbalance controls a servo which positions the potentiometer shaft. At balance, the position of this shaft is an accurate measure of the input frequency. The basic circuit is shown in Fig. 1. The operation of this circuit at balance may be explained very simply if the diodes D_1 and D_2 are assumed to be perfect switches.

The driving circuit provides currents of about 1 milliampere, which alternately charge and discharge C_1 during each cycle of input signal. The charging current

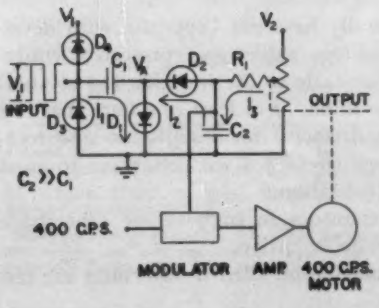

Fig. 1. Basic diode pump.

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958 at a session sponsored by the AIEE Electronics Committee.

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Acknowledgment is made to N. F. Moody and P. M. Thompson of the Defence Research Board of Canada for their help and suggestions and to Link Aviation, Inc., for assistance in the preparation of this article.

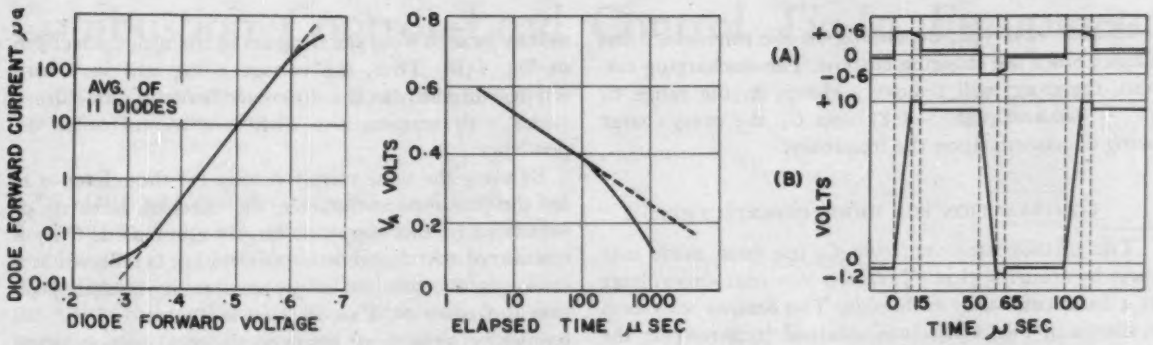

Fig. 2 (left). Silicon diode forward characteristics. Fig. 3 (center). Decay of V_a. Fig. 4 (right). Required waveforms: (A) Pump, (B) Input.

i_1 flows through C_1 and D_1, the discharging current i_2 through C_2, D_2, and C_1. The voltage through which C_1 may swing is limited by the diodes D_3 and D_4 to a peak-to-peak value of V_1. Each discharge current takes a charge $Q_1 = C_1V_1$ from C_2. In one second, charge fQ_1 is removed from C_2, where f is the input frequency. This is an average current of fQ_1 amperes. The voltage across C_2 is held at zero by the injection of an equal current through R_1. This current is $i_3 = v/R_1$, where v is the voltage at the tap of the potentiometer. Hence, at balance,

$$v/R_1 = f\,C_1\,V_1$$

or

$$v = C_1\,R_1\,V_1\,f \tag{1}$$

In order for v, and therefore the potentiometer shaft rotation, to be proportional to f, it is necessary that C_1 R_1 V_1 be constant for all frequencies and temperatures within the specified ranges. C_1 and R_1 are independent of frequency in the audio range and are chosen with equal and opposite temperature coefficients. V_1, the voltage swing of C_1, must be stabilized.

However, diodes which act as perfect switches were assumed during the derivation of equation 1. Real diodes conduct reverse leakage currents and have forward voltage drops. It is necessary to examine the basic circuit to see what effect these diode imperfections may have on its operation.

DIODE IMPERFECTIONS

Silicon junction diodes have been used in the final circuit because, in the "off" condition, they are nearly perfect switches with leakage currents of about 10^{-9} amperes. In the "on" condition, they are poor switches requiring about 0.6 volt forward drop in order to conduct 1 milliampere.

Because of this large forward drop and because of the rapidly increasing diode resistance with reduced forward voltage, the basic circuit will not have the same initial conditions for each charging and discharging current throughout the 10-to-1 range of frequency. Consider only the discharging half of one cycle. When, at the end of a charging cycle, the capacitor C_1 (Fig. 1) is charged to voltage V_1, V_a will be approximately +0.6 volt. This voltage will decay at a rate

$$\frac{dV_a}{dT} = \frac{i_f}{C_1} \tag{2}$$

where i_f is the forward current through D_1. Below 100 microamperes, the forward current is given by the expression

$$i_f = i_s\,(e^{v/CKT} - 1) \tag{3}$$

where

v = V_a, the forward voltage

KT = energy equivalent of temperature

C = a constant dependent on diode construction

i_s = theoretical saturation current[2]

Fig. 2 shows this current–voltage relation for 11 typical silicon diodes.[3] From equation 2 and 3 it can be shown that V_a decays logarithmically. This is illustrated in Fig. 3 which is a plot of V_a against the logarithm of time. As V_a falls below 0.3 volt, surface leakage (not accounted for in equation 3) begins to come into play. The value of i_f is greater than equation 3 states and, hence, V_a falls more rapidly than is predicted by equations 2 and 3.

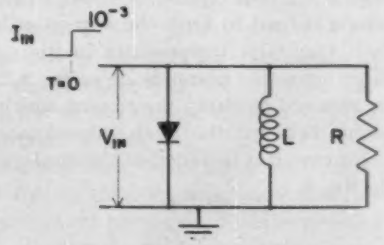

Fig. 5. Step-forming circuit.

The linear relation between potentiometer voltage v and the input frequency f expressed in equation 1 does not hold because of the slow decay of V_a. At the start of a discharge cycle, this voltage will be somewhere between

+0.5 and +0.2 volt, depending on the time which has elapsed since the charging current. The discharging current, therefore, will remove a charge in the range C_1 $(V_1 - 0.5)$ to C_1 $(V_1 - 0.2)$ from C_2, the exact charge being dependent upon the frequency.

COMPENSATION FOR DIODE IMPERFECTION

THE CHARGE REMOVED from C_2 has been made constant by ensuring that V_a returns to a near-zero voltage at a fixed time after each edge. The desired waveform is shown in Fig. 4 (A). It is obtained by arranging the limiter so that within 5 microseconds after each charging or discharging, the input voltage will fall about 0.6 volt. The necessary waveform is shown in Fig. 4 (B). The 0.6-volt step is obtained from the circuit of Fig. 5.

Immediately upon the application of a 1-milliampere step of input current, the diode of Fig. 5 conducts almost all the current and V_{in} rises to 0.6 volt. The series resistance of the choke being low, the current in L rises linearly at the rate V_{in}/L amperes per second. The diode

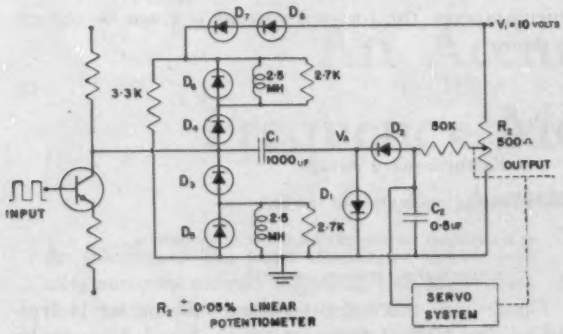

Fig. 6. Final circuit diagram.

drop changes little until the choke is conducting 9/10 of the current. This occurs in about 4 microseconds, after which V_{in} falls rapidly to about 10 millivolts. A silicon diode is used to form the step in order that its height will vary with temperature in the same way that the drop across the pump diode varies. A 2.7-kilohm resistor is required to clamp the ringing which would otherwise occur between the diode capacitance and the choke. This circuit is included in the final pump circuit shown in Fig. 6.

TEMPERATURE AND SUPPLY VOLTAGE COMPENSATION

TWO MINOR ADDITIONS to the basic circuit insure that the input voltage swing is largely independent of temperature and that the supply voltage variations will have little effect on the linearity. The first objective is achieved by adding two extra silicon diodes into the reference supply. When this is done, the discharging current reduces the voltage across C_1 by the reference supply V_1 plus the voltage drop across diodes number 3, 4, and 5 less the drops across diodes number 2, 7, and 8, as may be seen from the diagram of the input waveform in Fig. 4 (B). Thus, the voltage swing will vary with temperature only as the *difference* between diode drops varies with temperature. This is a second order dependency.

By using the same supply voltage for the reference as for the linear potentiometer, the effect on linearity of variations in this supply is largely eliminated. Only a fraction of any change in supply voltage is reflected as a change in the constant of proportionality of shaft position to frequency. This fraction is the ratio of the difference between diode drops to the total voltage swing and is less than 0.008 and is more probably less than 0.004. The supply voltage is stabilized to $\pm 5\%$.

DETECTOR

IN ORDER TO MEASURE the range of frequencies around 2 kc, C_1 and V_1 were arbitrarily chosen equal to 1,000 microfarads and 10 volts. This makes $R_1 = 50$ kilohms for a full shaft rotation representing 20 kc.

Hence, the maximum current flowing into the storage capacitor is $V_1/R_1 = 200$ microamperes. In order to maintain balance to $\pm 0.1\%$ of full scale, the servo system must operate with a signal of less than ± 0.2 microamperes. The detector used is the modulator described by N. F. Moody[3] which can reliably detect signals of ± 0.01 microampere.

CONCLUSION

REFERRING BACK to equation 1, $v = C_1 R_1 V_1 f$. Now, $v = rV_1$, where r (< 1) represents the fractional rotation of the potentiometer shaft. Therefore, $r = R_1 C_1 f$, with the errors noted previously.

The circuit shown in Fig. 6 has been built using a linear potentiometer which was calibrated with a potential divider to $\pm 0.01\%$ and tested over a frequency range of 2 to 20 kc, as measured on an electronic counter to ± 1 cps. The shaft position was linearly proportional to input frequency with an accuracy of $\pm 0.04\%$ of full scale at any temperature and the constant of proportionality changed by 0.1% between −55 C and +55 C.

SUMMARY

BY ACCURATELY CONTROLLING the conditions at the start of each discharging current, by compensating for temperature variations in the critical limiting and current-defining components, and by balancing supply voltage variations, we have constructed an instrument which will automatically convert frequency into shaft position with an accuracy of $\pm 0.1\%$.

REFERENCES

1. Waveforms (book), B. Chance, et al. MIT Radiation Laboratory Series, vol. 19, McGraw-Hill Book Company, Inc., New York, N. Y. 1949.

2. Electrons and Holes in Semiconductors (book), W. Shockley. D. Van Nostrand Company, Inc., Princeton, N. J., 1950.

3. A Silicon Diode Modulator of 10^{-8} Ampere Sensitivity, N. F. Moody. *Proceedings*, National Electronics Conference, Chicago, Ill., 1955.

Combustion Control–Load Control Tie-In Equipment

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FREQUENTLY, when automatic load control has been applied to a turbine–generator, regulating performance of the unit has been limited by the ability of the boiler to keep up with the load changes. The purpose of this investigation is to evaluate the improvement in boiler response realized by sending load-regulating intelligence to the boiler as well as to the turbine. The results of a computer simulation study of the problem are verified by a comparison with actual field performance.

The control equipment involved in the evaluation is shown in Fig. 1. Unit 1 at the Niles Station of the Ohio Edison Company is a reheat machine with a maximum gross hourly output of 125 megawatts. It is supplied with steam at 1,480 pounds per square inch and 1,000 F by a cyclone-fired Babcock & Wilcox boiler. With reference to the combustion control equipment shown at the left, the pressure controller normally determines the proper value of input or coal-feed solely on the basis of variations in throttle pressure. At the right, the system load control equipment, located at the Massillon load dispatcher's office, detects variations in customer load on the Ohio Edison system and originates raise and lower control signals. These are routed by the station control equipment to the Unit 1 turbine governor motor. The tie-in equipment shown with dotted lines makes this information also available to the boiler control.

An analog computer was employed to assist in planning field tests to indicate the approximate results. It was possible to simulate control performance with sufficient accuracy on the computer to permit a substantial reduction in field testing time. The expected performance under unusual circumstances can be analyzed thoroughly on the computer without subjecting the unit to all of these disturbances. It is still desirable, of course, to run selected field tests for a final check to substantiate the simulated results, but for many problems, much of the time-consuming field work can be eliminated.

On this unit, the results obtained in the field at full load with the combustion control by itself are quite satisfactory. The only visible benefit of the tie-in equipment at full output appears to be slightly improved pressure regulation. However, as the load on the unit is reduced, the pressure deviations with the combustion control by itself become larger than at full load. There are two reasons for this. First, the pressure drop in the main steam line between the boiler drum and the turbine throttle is very much reduced at lighter loads. This pressure drop varies as the square of the steam flow and it provides less load change intelligence for the combustion control to work on without the assistance of the tie-in equipment as load is decreased on the unit. Second, pressure variations have to be greater to follow

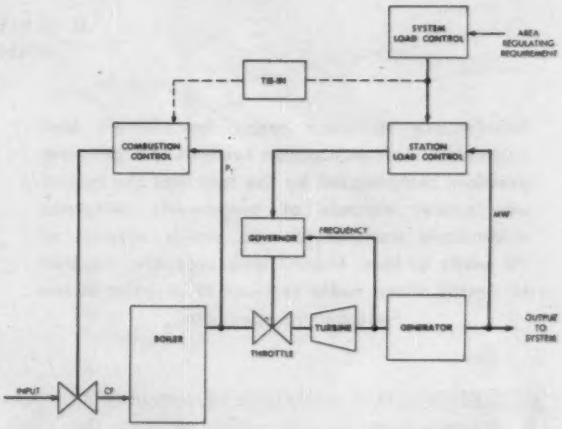

Fig. 1. Block diagram of Unit 1 Niles Station.

the same load pattern, since there are fewer cyclones in service and the combustion control has less coal-feed equipment available to follow its output.

However, when the tie-in equipment is in service at reduced loads, pressure deviations are substantially less. Variations in pressure from modulation of the pipe drop by throttle motion have become smaller. Also, since the tie-in equipment is designed to recognize that there are fewer cyclones in service, the resulting signal can correct fuel input without direct assistance from the steam pressure controller. Thus, the pressure deviations can be quite small and average zero during any load change period.

The effect of the tie-in equipment on megawatt response at reduced unit output is to minimize overshoot after the load control impulses stop. For example, without the tie-in equipment at 60% load, a period of approximately 40 seconds is required for the megawatt output to reach a steady value after the last load control impulse. With the tie-in equipment in service, this response lag is negligible.

The conclusions of the study, based on actual field results and substantiated by the computer, show that this tie-in equipment enables the plant generation to respond more quickly and precisely to the load control signals over a wide load range. Thus, there is a definite benefit to the Ohio Edison System in meeting its instantaneous regulating demands.

Digest of paper 58-168, "Evaluation of Combustion Control–Load Control Tie-In Equipment," recommended by the AIEE System Engineering and Power Generation Committees and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, Aug. 1958, pp. 417-25.

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Radar Interference to Microwave Communication Services

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Interference between radar transmitters and microwave communication systems is a growing problem complicated by the fact that the former use power outputs of megawatts, whereas microwave transmitters use power outputs of 10 watts or less. Urgent measures are required to permit these radio services to co-exist in the microwave spectrum.

ALTHOUGH A NUMBER of cases of radar interference have been experienced over the years since the war, it was not until late 1954 that the seriousness of the problem was fully recognized in the telephone industry. During that year, severe radar interference was experienced to a *TD-2* microwave system operated by the Pacific Telephone and Telegraph Company for transmitting television signals from Los Angeles, Calif., to Las Vegas, Nev.

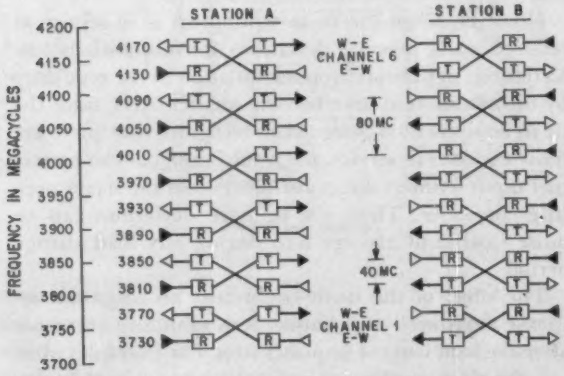

Fig. 1. *TD-2* radio systems channel frequency arrangement.

Two general types of interference are involved: (1) that resulting from the operation of radars directly on fundamental frequencies used for communication services and (2) that caused by the generation and radiation by the radars of spurious frequencies including harmonics which fall in bands and on frequencies used for communication services. The former type of interference can be eliminated through control of the frequency assignments for both radar and communication purposes. The latter type, however, is not as readily disposed of.

The *TD-2* microwave system which was developed by Bell Telephone Laboratories was first placed in operation between New York and Chicago in September 1950. It operates in the frequency range 3,700-4,200 mc and is designed to handle from one to 12 broadband channels, six in each direction of transmission along a route.

One of the frequency plans extensively used for the *TD-2* system is that shown in Fig. 1. As indicated, in a given direction from a repeater station, the receiving frequencies are spaced by 80 mc and are centered between the transmitting frequencies which are also 80 mc apart. For branch routes intersecting at small angles, frequencies in between those shown are used to avoid interference. Ordinarily four antennas are employed at each repeater station, one pointed each way for transmitting and one each way for receiving. On some light routes, a single antenna pointed each way may be used for both transmission and reception.

The *TD-2* system employs frequency modulation with a power output of only ½ watt for each broadband channel. Two such broadband channels, one for each direction of transmission, normally handle up to 600 telephone circuits or two television signals.

The route from Los Angeles to Las Vegas on which the radar interference was experienced was used for one-way transmission on the frequencies 3,790 and 3,830 mc. Fig. 2 shows the location of this route. The interfering radar signals were entering the receiving antenna of the repeater at Strawberry Peak together with the desired signals on 3,790 mc. The radar signals were traced to spurious radiations of an "S" band acquisition radar located in Los Angeles some 60 miles away.

As a result of this experience, Bell Laboratories undertook an investigation of the causes of radar interference and means for avoiding or minimizing such interference. This effort was directed along the following lines:

1. Determination of the effect of radar type emissions on the *TD-2* microwave system.
2. Study of the radiated frequency spectrum of certain high power radars in use or planned for use by the military.
3. Investigation of means of suppressing the spurious and harmonic radiations from the radar emissions.

Essentially full text of paper 58-817, recommended by the AIEE Radio Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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EFFECT OF RADAR SIGNALS ON *TD-2* SYSTEM

THE FIRST OF THESE STUDIES was carried out in the Laboratories by injecting varying known amounts of pulsed radar type signals into the crystal mixer in the head end of a *TD-2* receiver, together with a simulated multichannel telephone signal corresponding to that normally received over an average microwave path. The results of these tests are illustrated in Fig. 3. It can be seen that as the peak value of the pulsed radar signal approaches the peak value of the desired signal, the interfering telephone circuit noise rises very rapidly from negligible amounts for carrier-to-interference ratios of 5 db or more, to intolerable amounts for carrier-to-interference ratios of −5 db or less. For the case of television, it was found that interference would result from radar signals 25 db weaker than those which cause interference to multiplex telephone circuits. The interference level for circuits carrying SAGE data signals is estimated to be about the same as for telephone. Although the foregoing tests were conducted on a *TD-2* receiver, field tests with other types of microwave equipment indicate similar effects.

Fig. 4 shows the effect of radar interference on a television picture. The separation between the dashes of interference seen in this picture depends on the radar repetition rate and the length of each dash depends on the radar pulse length. In a telephone circuit, the interference is evidenced by a rough buzzing noise.

EXTRA BAND RADIATION

THE BELL LABORATORIES investigation of radar frequency spectrum characteristics was carried out with the aid of a Polarad receiver with four r-f heads mounted in a truck with calibrated horns on the roof. The receiving equipment was capable of adjustment to any frequency in the range 2,100 to 11,260 mc. Fig. 5 is a photograph of the test truck. Attenuators were provided to prevent overloading the receiver with strong radar signals. The truck was also equipped with an oscilloscope to observe the signals being measured, and a pulse generator which was used to simulate the radar signals and determine their amplitude by the substitution method. Through co-operative arrangements with the U. S. Army, Navy, and Air Force, measurements using this equipment have been made on a number of radars commonly in use or under construction. The radars studied included nine different types, one using a klystron and the others using magnetrons as the frequency generating source. The power output at the fundamental frequencies ranged from 0.14 to 5.0 megawatts. All of the units tested were found to be radiating spurious products of very substantial magnitude. The results of these tests are shown in the mass plot of Fig. 6 in which each harmonic and spurious product is shown as a point indicating its magnitude or power as ordinate vs the ratio of its measured frequency to the fundamental frequency of the radar as abscissa. As indicated, the spurious emissions range up to as much as 93 dbm effective radiated power, while many of the products

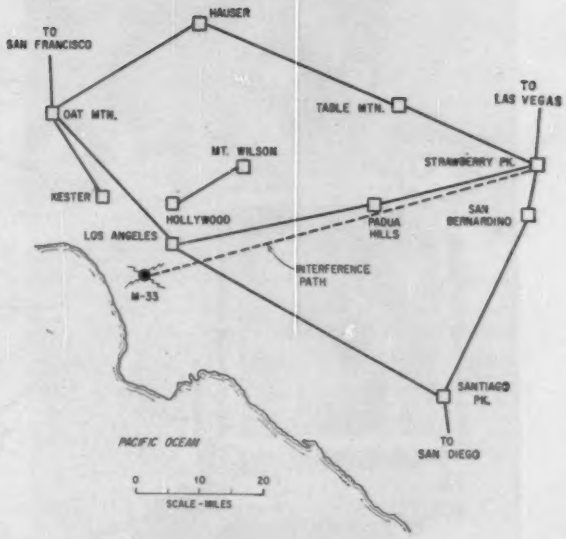

Fig. 2. M-33 radar and microwave routes, Los Angeles, Calif., area.

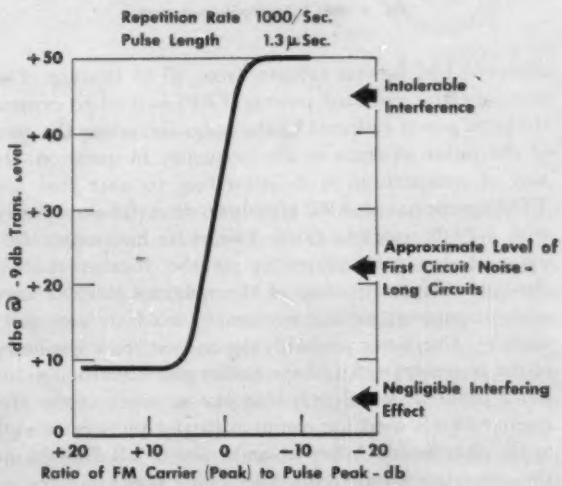

Fig. 3. Effect of r-f pulse interference on the *TD-2* system.

Fig. 4. Radar interference to television signal.

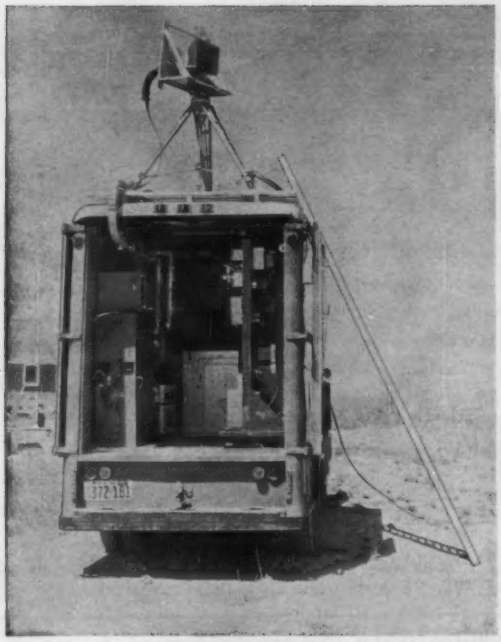

Fig. 5. Bell Laboratories test truck.

observed had powers ranging from 40 to 70 dbm. The term effective radiated power (ERP) is used to express the peak power radiated by the radar including the gain of the radar antenna at the frequency in question. By way of comparison, it is interesting to note that the *TD-2* system has an ERP of only 66 dbm (0.5-watt power with a 39-db antenna gain). The radar harmonies shift up and down in freqüency as the fundamental is changed. Similarly, some of the spurious outputs vary with magnetron tuning; others are fixed, or vary only slightly. The latter probably depend on some geometry of the magnetron. All of the radars tested emitted extra band products which fell into one or more of the frequency bands used for common carrier services as well as in other bands. When these products fall directly on the communication frequencies being used, receiver selectivity affords no protection and the only means of avoiding interference is by antenna directivity; shielding by hills, trees, buildings or other obstructions; and by physical separation of the radars from the communication receivers. Fortunately, most *TD-2* stations employ well-shielded horn reflector or delay lens antennas, the directive characteristics of which are shown in Fig. 7. While such antennas greatly minimize the possibilities of interference from radars not directly in line with the receiving path, they are not capable of completely protecting against spurious emissions of powerful radars even though located "off-beam" at considerable distances.

MAGNITUDE OF PROBLEM

BASED ON THE PREVIOUSLY MENTIONED MEASUREMENTS of the radar radiation characteristics and their interfering effect on the *TD-2* system, it is possible to estimate

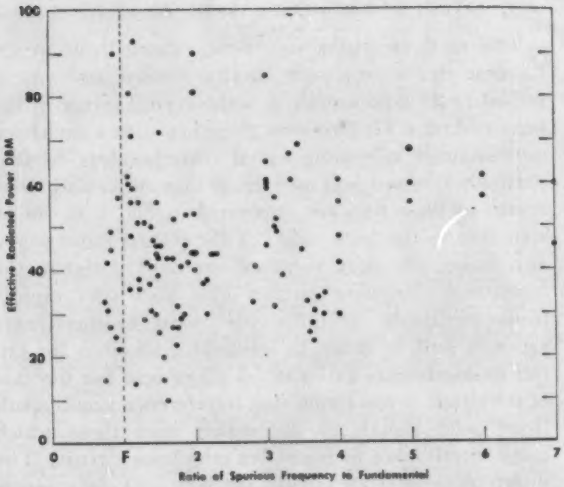

Fig. 6. Distribution of measured spurious and harmonic products of nine radars.

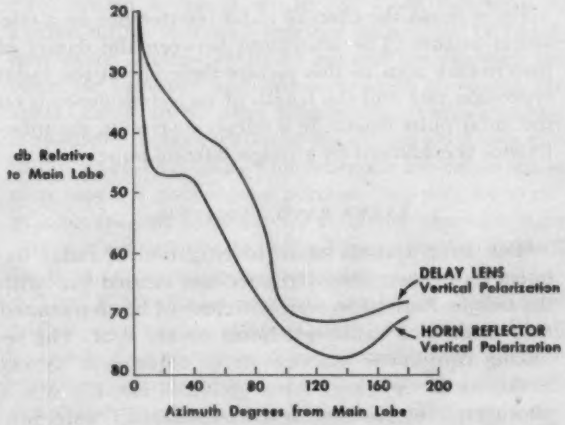

Fig. 7. Directive patterns of horn reflector and delay lens antennas.

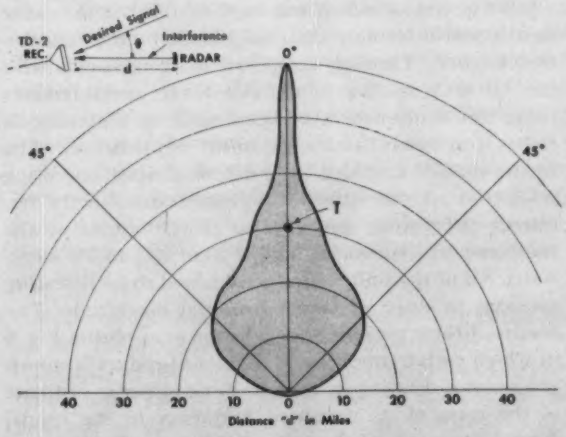

Fig. 8. Zone of radar interference to TD-2 receiving station. Radar spurious of 45 dbm ERP on television channel or 70 dbm ERP on telephone channel.

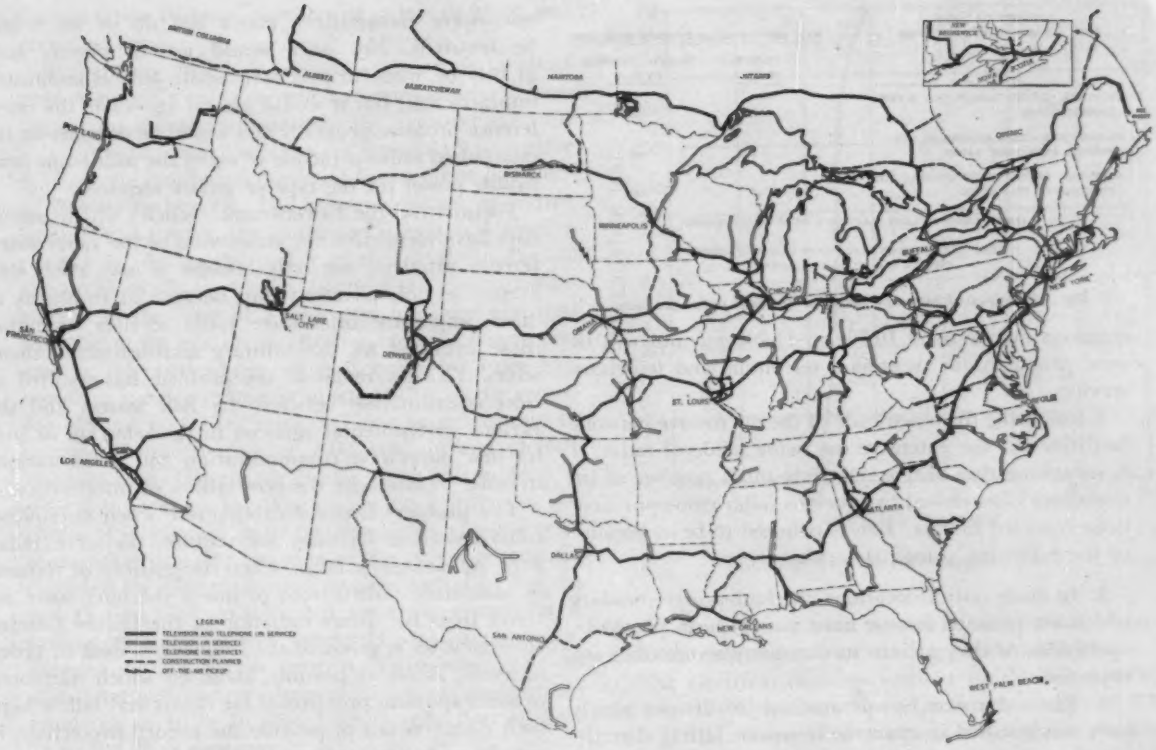

Fig. 9. Broadband microwave radio relay systems (Bell and connection routes).

whether interference will result from a radar at any specific location. Fig. 8 gives a graphical illustration of the extent of the interference areas that may be involved. This is a polar diagram centered on a *TD-2* station receiving signals over a nominal 30-mile path from a *TD-2* transmitter at point *T*. A radar transmitter emitting a spurious signal of 45 dbm ERP on a receiving channel being used for television reception may cause interference if it is located within the cross-hatched area. The same area also applies to the case of a radar transmitter emitting a spurious signal of 70 dbm ERP on a receiving channel being used for telephone operations. As indicated on Fig. 6, many of the radars have spurious products as big or bigger than those assumed. The cross-hatched area was calculated on the assumption that line of sight transmission exists for distances up to 30 miles with beyond-the-horizon smooth earth transmission losses applying at greater distances. Fading of the desired signal of 30 db was also used in these calculations because the *TD-2* system is designed to provide service in the presence of fades of this magnitude.

Considering the very appreciable size of the interference area indicated on this figure, and the extensive use being made of microwave radio to provide the nation's communication needs, the reason for concern about the radar interference problem becomes apparent. Of all the microwave communication systems in service today, the Bell System alone operates more than 30,000 route miles consisting of some 1,300 individual stations scattered throughout the country. These facilities are used to provide 62,000 miles of intercity television circuits and about 13 million miles of long distance telephone circuits. These circuits which have been installed in a period of only 8 short years comprise 80% of all the intercity video and about 25% of all long distance telephone circuit mileage in the Bell System plant.

In addition to providing long distance telephone and television services, these circuits are used for important industrial and governmental private line services. The bulk of these circuits are provided by broadband microwave facilities, mostly *TD-2* which operates in the 4,000-mc common-carrier frequency band. Fig. 9 shows the widespread extent of this broadband microwave network. In addition to the routes shown, the Bell companies operate a large number of short-haul narrow-band microwave systems carrying up to a few dozen circuits each. These systems operate in the 890–940 and the 5,925–6,425 mc bands. Extensive use of the latter band for long-haul heavy route service is also planned by use of the *TH* microwave system which has been developed by Bell Laboratories. This system can be used to increase greatly the capacity of existing *TD-2* microwave routes or for the establishment of new routes. The Laboratories have also developed a new microwave system known as the *TJ* system, which is being introduced into the plant this year. This system operates in the

LOCATION OF RADAR WITH RESPECT TO TD-2 RECEIVERS	MAX. ERP* OF RADAR SPURIOUS PROD.-DBM	
	TV CHANNELS ON TD-2	TELEPH. CHANNELS ON TD-2
ANYWHERE, EXCEPT CLOSER THAN A FEW HUNDRED YARDS	-35	-10
ON SAME SITE - TD-2 ANTENNA AT SITE POINTED AWAY FROM RADAR	+ 5	+30
ANYWHERE, EXCEPT ALONG ONE MILE STRIP CENTERED ON TD-2 ROUTE	+15	+40

(ABOVE LIMITS INCLUDE ALLOWANCE OF 30 DB FOR FADING)

* EFFECTIVE RADIATED PEAK POWER INCLUDING RADAR ANTENNA GAIN AT TD-2 FREQUENCY.

Fig. 10. Estimated tolerable levels of spurious radar products.

common carrier band 10,700 to 11,700 mc and will be used primarily for short-haul telephone and television services.

Considering the magnitude of the microwave network facilities and the extensive use being made of radar, it is surprising that only a relatively small number of interference cases caused by spurious radar emissions have been reported to date. This is believed to be so because of the following principal factors:

1. In many critical locations, the high-powered radars which are planned for use have not yet been placed in operation. As they go into service many severe cases are expected.
2. The radar may be operated on frequencies which have not resulted in spurious emissions falling directly on channels being used at exposed microwave stations. (Military considerations make frequency changes desirable.)
3. Many of the microwave receiving sites are shielded from the radars by hills, trees, or man-made obstructions.
4. On lightly loaded routes, the receiving frequencies used may be selected to avoid the unwanted radar products. This is not possible on heavy routes.
5. Some of the operating people may not be fully aware of the nature of radar interference and may have failed to report it. Radar interference causes noise on telephone circuits and pigeons or other effects on television signals, similar to effects which sometimes arise from other causes.
6. The radar or the communication facility may be used only part time, with the result that interference is avoided or is only intermittent.
7. Where the interference level is such that it is troublesome only during fading periods, the chance of identification is greatly reduced.

MEASURES BEING TAKEN

THE QUESTION NATURALLY ARISES as to whether radar interference to microwave systems might be minimized by increasing the power used by the communication systems. Consideration of this possibility indicates that it would not provide a satisfactory solution. The receiver sensitivities used are generally of the same order of magnitude as those used by radar receivers. To overcome interference from severe exposures to radar spurious emissions, a terrific increase in the power of present microwave transmitters, about 100 db or so, would be required. Not only would use of powers such as this be wasteful and technically and economically impracticable, but it would greatly aggravate the interference problem generally and would be contrary to the established radio principle of using the minimum practicable power for the type of service required.

Fortunately, the Government agencies which use radars have recognized the seriousness of the radar interference problem, not only because it may affect Bell System services adversely, but because of its threat to other important microwave radio services including those operated by the military establishments themselves. This awareness of the problem has resulted in close co-ordination between the Bell System and the various governmental agencies in the selection of sites for new microwave communication and radar stations in order to minimize the possibilities of interference.

The problem is particularly severe when microwave communication facilities are required to serve radar sites. Advantage is taken wherever possible of natural or man-made obstructions to shield the microwave receiver from the direct radiation of the radars. Careful consideration is given to the frequencies used in order to avoid, as far as possible, those on which harmonic or other spurious products of the radars may fall. Where such measures fail to provide the needed protection, it may be necessary to try special shielding of the communication receiving antennas, limitation of the frequency tuning ranges of the radars, or the use of sector blanking of the radars to prevent transmission directly toward the communication receiver.

It is recognized that such measures can only be temporary expedients at best. With the growing use in this country of both microwave communication services and radars, coupled with the trend toward higher powers for radar transmitters, it is obvious that means must be found to suppress radar radiations on frequencies outside the bands in which they are intended to operate to values which are not likely to cause interference to other services. Such measures will not only give greater freedom in the selection of interference-free sites for radar and communication facilities, but also will minimize the problems of mutual interference arising from

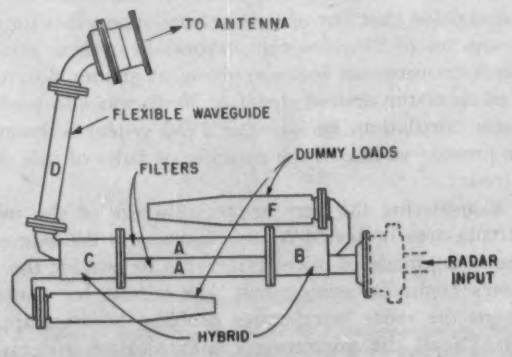

Fig. 11. Filter assembly for M-33 radar.

the operation of large numbers of radars in given geographical areas.

Recognizing that it is probably impossible to eliminate completely spurious and harmonic products from the output of radar transmitters, the question naturally arises as to how much suppression is necessary to achieve keeping the interfering potentialities of the radars within reasonable bounds. The answer depends, of course, upon the characteristics of the facilities it is desired to protect as well as the power of the radar. In Fig. 10 the problem of interference to the *TD-2* system is considered in the form of a table and has been prepared to indicate the maximum effective radiated power that can be tolerated under various conditions from harmonic or spurious radar products falling in the receiving channel of a *TD-2* station. These figures assume an average 30-mile spacing of *TD-2* stations and include an allowance of 30 db for fading. From this table, it is seen that in order to allow maximum freedom in the choice of location of radar stations and microwave communication sites, the emission of the radar on frequencies used for communication services should be limited to −35 dbm ERP. As indicated, somewhat greater levels can be tolerated where geographical separation and antenna discrimination permits. To achieve the −35 dbm level with radars currently in use having spurious emissions of 40 to 70 dbm ERP, a reduction of some 75 to 105 db is necessary.

MEANS OF SUPPRESSION

Recognizing the seriousness of radar interference, the military services have initiated studies in their own organizations and through contracts with manufacturing, engineering and development organizations seeking a solution to this problem. As part of the effort, Bell Laboratories has undertaken studies of means of suppressing the unwanted radiations from the *M-33* radar. In this work, consideration was given to the possibility of suppressing the spurious signals within the magnetron, the use of pulse shaping techniques and by use of a high-power filter in the transmitter output. These studies indicated that the most practicable approach for the *M-33* was the development of a high-power filter. Investigation of this method has led to the design of a nonreflecting type of filter which preserves the transmitter stability in the mode frequency part of the spectrum.[1] Fig. 11 shows a cross-sectional view of the filter. The complete assembly consists of two identical evacuated filter sections *A* coupled through two carefully balanced hybrids in such a manner that the transmitted signal entering the input hybrid *B* will follow one of two paths. Signals in the pass band will divide equally through the two filter sections, recombine in the output hybrid *C*, and be transmitted to the antenna through a short section of flexible waveguide *D*. Signals in the stop band will be reflected at the filters, recombined in the input hybrid and be dissipated in the input dummy load *F*. The output dummy load will absorb no power with a perfectly matched system but is required to handle reflections and mismatches in the output end of the filter, which result from manufacturing tolerances and possible malfunctions in the waveguide assembly.

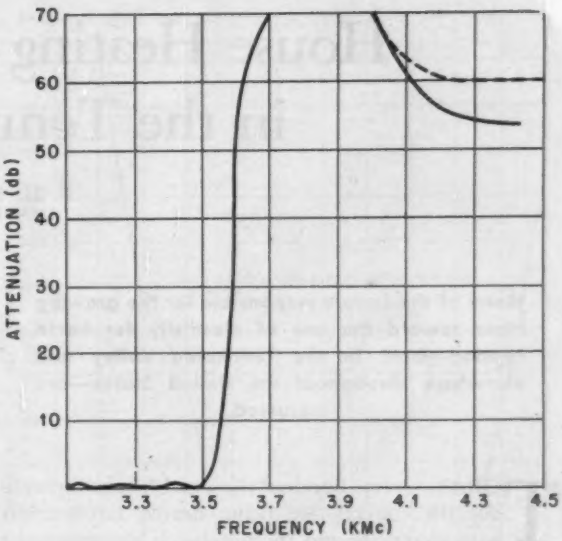

Fig. 12. Filter characteristic.

The electrical characteristics of the filter are shown in Fig. 12. This figure shows an insertion loss of 0.50 to 0.75 db over most of the passband with an increase to just under 1.0 db at the ends of the band at 3,100 and 3,500 mc. The attenuation increases sharply above the passband to more than 70 db at 3,700 mc, the lower edge of the band used by the *TD-2* radio relay system. The attenuation remains above 70 db from 3,700 to 3,950 mc and then falls off to a plateau of about 65 db up to at least 4,500 mc. Although a single filter of this design will not reduce the *M-33* spurious products sufficiently to meet the −35 dbm objective fully, it will greatly reduce the likelihood of interference from this type of radar.

CONCLUSIONS

Continued work on the radar interference problem is necessary if the usefulness of the radio spectrum for general communication purposes is to be preserved. This work divides into two parts: (1) that required for the development of means of suppressing unwanted emissions from existing radars to eliminate interference situations as they arise and (2) development of improved techniques for the design of new radars which will result in elimination of or great reduction in spurious products at the source. Just as other interference problems threatening to limit seriously the usefulness of the radio spectrum have been overcome in the past, so we are confident that engineering techniques will be developed to conquer the radar interference problem.

REFERENCES

1. Evacuated Waveguide Filter for Suppressing Spurious Transmission from High-Power S-Band Radar, H. A. Wheeler, H. L. Bachman. To appear in IRE *Transactions on Microwave Theory and Techniques*, Vol. MTT-7, No. 1, Jan. 1959.

House Heating with Electricity in the Tennessee Valley

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Many of the factors responsible for the growing trend toward the use of electricity for home heating—both in the Tennessee Valley and elsewhere throughout the United States—are discussed.

TODAY, several hundred thousand homes throughout the country are being heated satisfactorily with electricity and the number is growing quite rapidly. Five years ago the majority of electrically heated homes were concentrated in only a few areas, but now the use of electric heating is spreading into many places where there was none as recently as two years ago. A number of factors are responsible for this widening use. Among the more influential of these is the increasing cost of fuels and the tremendous growth of summer air-conditioning loads on electric distribution systems. Many electric utilities are actually promoting heating to offset the summer peaks created by air conditioning.

In the Tennessee Valley, the number of homes using electric heating is rapidly approaching the 200,000 mark. The most recent estimate indicates over 177,000 homes with complete electric heating systems. This represents a saturation of about 14 per cent. We do not know how many homes are using electricity for auxiliary heating, or for "chill chasing" in the Fall before the fuel-fired furnace is placed into operation, or in the late spring after the furnace has been shut down.

Fig. 1 shows the annual growth in the number and saturation of electrically heated homes in the area served by the distributors of TVA (Tennessee Valley Authority) power from 1948 up to the beginning of 1957. Of these electric systems, 51 are co-operatives.

As might be expected, the majority of these electrically heated homes had the systems installed at the time the home was being built. Generally speaking, the old houses are poorly insulated and conversion to electric heating is expensive; however, electric heating has been installed in older houses when they were well constructed and after suitable thermal insulation was provided.

Some indication of the number of new electrically heated homes which have been built during the last five years in areas served by the co-operatives in the Tennessee Valley may be obtained from Table I, which shows the annual increase over the previous year in residential consumers and electric heating installations in TVA areas served by co-operatives.

Table I. Growth of Residential Consumers and Electric Heating Installations

January	Residential Increase	Electric Heat
1953	22,400	4,700
1954	16,200	3,900
1955	13,900	3,700
1956	9,300	5,200
1957	11,270	5,000*

*Preliminary estimate

It may be noted that in the last two years the increase in electrically heated homes was about 50 per cent of the new consumers added during the same years. In some of the municipal areas, from 80 to over 90 per cent of the new homes which have been built within the last five years are heated electrically.

A utilization specialist working with one of the rural electric co-operatives in northern Alabama reported that of 105 homes for which he made electric space heating recommendations during 1956, 103 installed complete electric heating. This co-operative, whose members are over 90 per cent rural, is located in an area where bottled-gas competition is very strong. Its average annual residential kilowatt-hour (kw-hr) use has increased from 1,384 in 1950 to 4,502 as of June 30, 1957. This 225 per cent increase in average annual use has resulted largely from increased use of electricity for house heating along with aggressive promotion of major home appliances.

ADVANTAGES OF ELECTRIC HEATING

THIS HAS HAPPENED even though other means of heating were considered to be cheaper. This has been generally true from a cost-of-operation standpoint, but there are many offsetting advantages to electric heating which are greatly appreciated by the users. Among the more important of these are cleanliness, accurate temperature control, and the almost complete freedom from attention during operation. The cleanliness of electric heat has a strong appeal to the housewife. The walls of an electrically heated home do not require redecoration as frequently as when other heating systems are used. Draperies, curtains, and rugs do not require cleaning and laundering nearly so often. All of this represents tangible savings and should be considered as a credit when estimating the over-all cost of electric heating in the home.

Essentially full text of a conference paper prepared for the AIEE Farm Electrification Conference, Minneapolis, Minn., Oct. 29-31, 1957. Recommended for publication by the AIEE Domestic and Commercial Applications Committee.

B. H. Martin is with the Tennessee Valley Authority, Chattanooga, Tenn.

Too, there is the advantage gained from the heat supplied by lighting, television, radio, and other electric appliances. Because these basic loads often supply a substantial portion of the heat requirements during mild weather, the electricity required for the heaters can be purchased at lower steps of the rate. There is no excuse for the family living in an electrically heated home not to have the best of lighting. When the current is used to produce light, heat is also obtained and therefore less current will be used by the heaters. With the increasing use of better lighting and appliances in the home, electric heating is made even more attractive.

Surveys, which we have made in co-operation with some of our power distributors, indicate very definitely that the consumers having electric heating are better year-round users of electricity. This is well illustrated by Fig. 2, which shows the average monthly energy use by residential consumers with or without electric heating as reported by 13 TVA power distributors. From this, we see that the average summer use by the residential consumers having electric heat is over twice that of the residential consumers without electric heat. The consumer with electric heat is more likely to cook and heat water with electricity than the one without. In fact, the home with electric heating is well on the road to becoming an all-electric home. The expanding use of summer air conditioning is now reaching the farm home along with all of the other modern conveniences which formerly were found only in the city home. A few days ago, I was told by one of the co-operative managers in our area that quite a number of the farm homes on his lines now have one or more room coolers, and some have installed complete air-conditioning systems. As this summer load grows, it will tend to produce a better year-round load in the home.

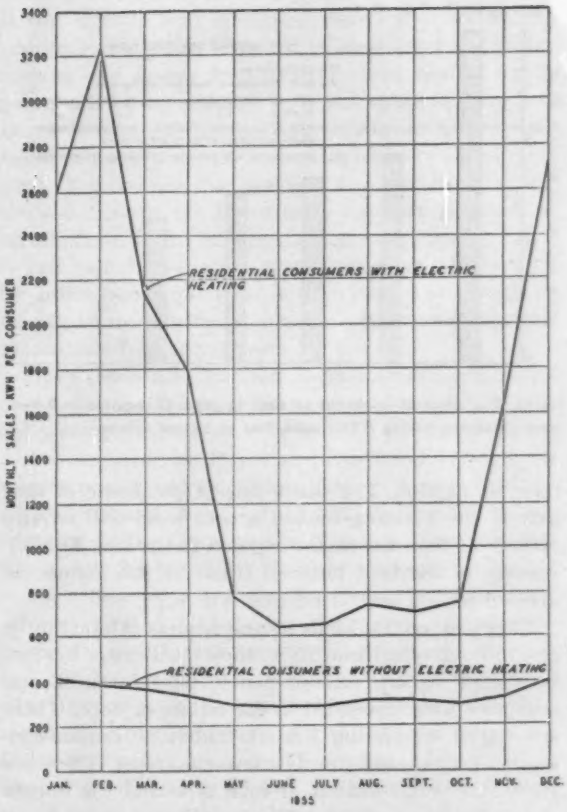


Fig. 2. Average monthly energy use—residential consumers with or without electric heating as reported by 13 TVA distributors.

HEATING SYSTEMS

MOST IMPORTANT in making electric heating feasible to both the user and the power supplier is proper application of a well-selected system for the type of construction of the home in which it is to be installed.

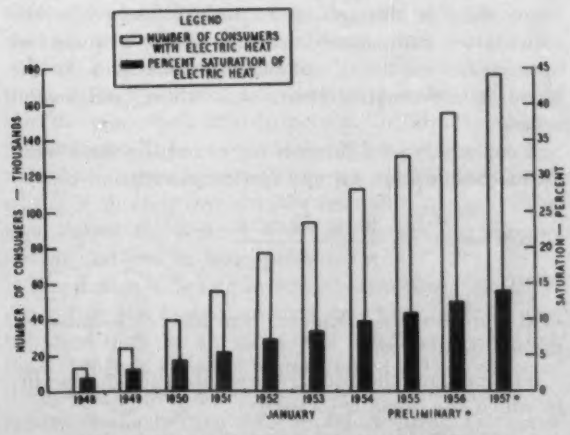


Fig. 1. Saturation of electric space heating among residential consumers served by municipal and co-operative distributors of TVA power.

Inasmuch as electricity is a high-cost form of energy for space heating, good building insulation is imperative. To install electric heating in poorly constructed or inadequately insulated homes will almost certainly result in dissatisfaction to the user and will be expensive to the power supplier.

Fig. 3 shows the effect of insulation on the capacity required for heating. This does not, however, reflect the added comfort which may be realized from good insulation.

Electric space-heating systems can be generally classified into two groups: central systems and those consisting of heating units installed in each space to be heated. With the central system, the heat is transferred to the various rooms by means of circulating warm air, water, or steam, and usually the regulation is by only one thermostat located at some central place in the house. With the use of separate units in each space, the temperature of each room can be, and usually is, individually controlled by wall thermostats located in the room or built into the heater itself. Because of the independent control for each space, systems using unit heaters will generally use less electricity and have better load characteristics than central systems. Better-regulated temperatures throughout the house can be had with individual room control. Heat will be provided in each

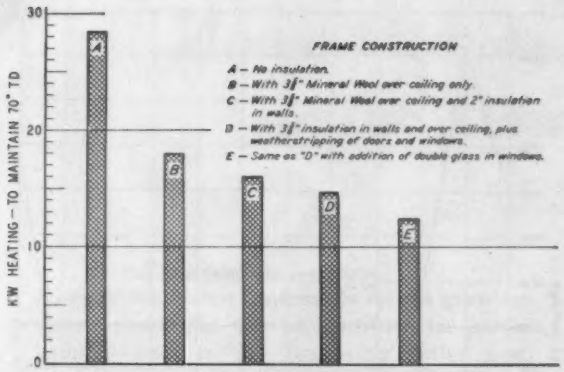

FRAME CONSTRUCTION
A — No insulation.
B — With 3½" Mineral Wool over ceiling only.
C — With 3½" Mineral Wool over ceiling and 2" insulation in walls.
D — With 3½" insulation in walls and over ceiling, plus weatherstripping of doors and windows.
E — Same as "D" with addition of double glass in windows.
KW HEATING — TO MAINTAIN 70° TD
30
20
10
0
A
B
C
D
E

Fig. 3. The effect of insulation on heating capacity required in 3-bedroom residence having 8,200 cubic feet of heated volume.

room as needed. The shady side of the house or that part of the building toward a cold wind will require more heat than the rooms exposed to the sun. Full advantage of the heat radiated from the sun cannot be utilized with a central heating system.

There are several kinds of unit heaters. These can be generally classified into six groups: wall insert heaters, baseboard heaters, radiant panels, floor furnaces, and resistance wire embedded in the ceiling or floor. There are forced circulating heaters, radiators, radiant-convection heaters, and strictly convection types. There are good and better heaters of each type and the one to choose for any particular job may depend on such factors as type of building construction, local availability, personal like or dislikes as to style of the heaters, and the price. A combination of type and make of heaters is often used.

The growing demand for summer cooling will influence the extent to which central systems will be installed since these provide a means of filtering or electrostatic cleaning of the air in addition to controlling temperature. The heat pump for year-round air conditioning will certainly become more generally used in the larger and more expensive homes.

Any modern new home, however, for which air conditioning is contemplated is a logical prospect for a heat pump installation, no matter what its size.

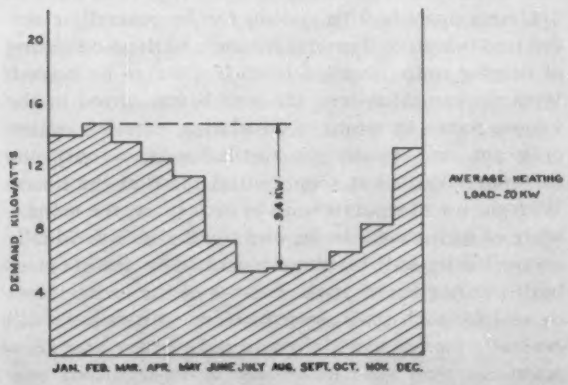


Fig. 4. Composite average monthly demands of five electrically heated homes on a rural co-operative system in Tennessee.

The heat pump is now an approved year-around air-conditioning device well beyond the experimental stage. Several reputable manufacturers are now making heat pumps and soon we may expect others to be added to the growing list. The number of heat pump units of all types now operating in the Tennessee Valley is estimated to be near 2,000. Approximately one half of these are in home installations. A large number of these units are on the lines of the co-operatives. One installation in a chicken hatchery has received wide publicity, and you may have read some of the articles dealing with this application. Eighteen of the municipal distributors and 16 of the co-operatives distributing TVA power are using heat pumps in one or more of their own bulidings. In the Tennessee Valley, 34 power distributors now have heat pump installations in their offices.

HEATING SYSTEM COMPUTATIONS

TECHNICAL DATA for use in making the computations for the capacity of the heating system to be installed are available from several sources. The "Heating Ventilating Air Conditioning Guide" contains tables giving heat loss coefficients of many building and insulating materials. The chapter pertaining to electric space heating for the 1958 issue of the "Guide" is now in the process of revision.

The Electric House Heating Equipment Section of NEMA (National Electrical Manufacturers Association) has available a "Manual for Electric House Heating" which is intended as a basic guide for the design of electric-heating installations. It also contains a chapter which discusses the method of estimating annual kw-hr consumption. Several manufacturers of space heating equipment have issued instruction booklets for use in determining building heat loss and designing heating systems for the proper application of their products.

The heat loss is influenced by a number of variables, such as geographic location, exposure to winds, design of the building, glass areas, number of outside doors, and allowance for air infiltration. The amount of electricity used is also subject to such influences as the temperature maintained inside the house, frequency of opening outside doors, number of people living in the home, wind velocities, hours of sunshine, and several others.

A commonly used formula for estimating the annual kw-hr consumption for any specific installation is

$$\text{annual kw-hr} = \frac{\text{hl} \times \text{dd} \times \text{c}}{\text{td}}$$

where

hl represents the calculated heat loss of the house expressed in kilowatts;

dd represents the annual degree days for the locality in which the home is located;

c is a constant representing the average hours per day during the heating season for which the full heating

load may be expected to operate. It can never be over 24 and usually varies between 15 and 20;

td represents the difference between inside and outside design temperatures in degrees Fahrenheit.

Having determined the annual kw-hr consumption by this method, the annual cost may be estimated by applying the local power rate.

The number of degree days for a normal heating season in Knoxville, as given in the U. S. Department of Commerce Weather Bureau's Climatological Data, is 3,590. Assuming a design temperature difference of 70 degrees and an average operating time per day of 18.5 hours for the full heating season as the value of c, a house having a heat loss equivalent to 15 kw (50,000 British thermal units per hour) would require 14,232 kw-hr to heat it during a normal winter. A central system having only one thermostat control might require from 15 to 20 per cent more. The demand characteristics of space heating loads are of particular interest to the power supplier. He is concerned as to how these affect both his investment required to render service and the annual load factor of his system.

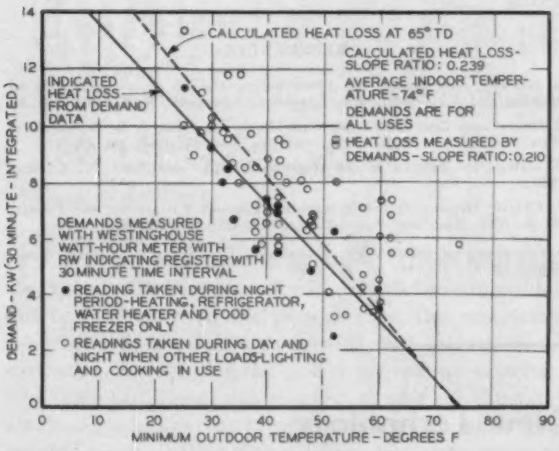


Fig. 5. Demand readings vs minimum outdoor temperatures taken during the months of December 1956 and January 1957.

Electric resistance heaters have, for all practical purposes, unity power factor. Resistance space heating loads are, therefore, beneficial in helping to improve system power factor. It has been observed that, in general, distribution systems have better power factors during the winter if there is considerable resistance space heating than during the summer when low power factor room coolers and similar loads predominate.

The demands created by space heating loads are highest during the coldest weather, at which time the distribution facilities are capable of handling the greater loads. Where a group of houses can be served from one transformer, there is the advantage of considerable diversity of the heating and appliance loads. On rural lines, where only one farm is served from one transformer, the diversity factor may still be surprisingly good if the farm is well equipped electrically. Often, the transformer capacity required to serve farm machinery, such as hay dryers, feed grinders, and similar equipment, will be adequate to serve the space heating load in the house. The heating load creates its heaviest demand at times when the electric machinery is not operated. One co-operative manager has established a formula to govern the transformer capacity required to serve a farm home having electric space heating. This is one half the installed heating capacity plus 4.8 kw for other household uses. A transformer rated nearest to this figure is selected. He has been using this rule successfully for several years.

Fig. 4 shows the composite average monthly demands of five electrically heated homes on his system. The average connected space heating load of the five homes is 20 kw. Applying his formula, the calculated size of the transformer would be 15 kva. You will note that the highest demand shown on the chart is 14.8 kw, which occurred during the month of February. Note also that this is only 9.4 kw higher than the demand during the summer months. All of the houses are insulated with mineral wool—4 inches over the ceiling and in outside walls. Four houses are of brick-veneer construction and one is frame type with siding. Two of the houses have six rooms, two have seven rooms, and one has nine rooms. The highest demand for this 9-room house was 19 kw with a summer demand of 5 kw. The connected space heating load is 28 kw. All heating installations are of the individual room unit type.

The average annual kw-hr consumption for the group was 19,700, and the estimated amount required for heating was 15,100 kw-hr. The normal heating season for this area has 3,500 degree days.

The average annual load factor of the group was 15.3 per cent, but without the heating and based on the summer demand, it was only 9.8 per cent. The annual load factor of the resistance heating alone was 18.3 per cent.

Fig. 5 shows demand readings as related to minimum outdoor temperatures taken during December 1956 and January 1957 in a home having a computed heat loss of 15.5 kw at 65 degrees temperature difference and an installed capacity of 16 kw. A special metering arrangement was installed and readings were taken at various intervals, at which time the demand indicator would be reset. A heat-loss line having a slope ratio of 0.210 was determined by readings made when the family retired and all lights, television, radio, and cooking appliances were off, then again the first thing in the morning before any of these appliances were turned on. Temperature readings both inside and outside of the house were made at the same time. It may be seen that the slope of the actual heat loss follows rather closely that made by calculation based on heat-loss formulas. Note also that the highest demand taken during the period was only 7.5 kw above that established in warmer periods by the basic loads in the home. This difference is 47 per cent of the 16-kw installed heating load. The

Table II. Annual Load Factor of Systems with High and Low Saturation of Electrically Heated Homes

System	Number of Heating Consumers	Per cent Saturation	Annual Load Factor
A	3,100	18.4	49.0
B	2,500	14.5	57
C	2,900	14.4	49
D	2,300	14.4	52
E	600	11.7	52
Average		14.7	51.8
F	100	1.0	52.0
G	80	1.0	54
H	50	1.0	51
I	40	1.0	50
J	20	1.0	55
Average		1.0	52.4

minimum outdoor temperature during the period when the highest demand was registered was 23 degrees. The temperature indoors during this period was 74 degrees, a difference of 51 degrees or 78 per cent of the design difference. The calculated increase in heating demand for an outdoor temperature of 10 degrees is 2.7 kw, which would raise the total demand to 16 kw.

How is space heating load affecting the annual system load factor of co-operatives, as the saturation of house heating increases? Table II shows the annual load factor for 1956 of five co-operative systems in the TVA area having the highest saturation of space heating load compared with the five co-operative systems having the lowest saturation of house heating load.

These figures indicate that house heating saturations up to 15 per cent do not significantly affect the system's annual load factor.

CONCLUSION

INDICATIONS are that the future growth of electric house heating will be widespread and greatly accelerated. Certainly that should be expected here in Tennessee Valley area. With emphasis on the comfort, safety, cleanliness, space saving, and carefree operation which result from the use of electric home heating, the public is demanding it. A housewife living in a farm home served by one of the co-operatives in Alabama stated that before they had electric heat she had to fuss with a coal stove in each room of a large farm house, which increased her housekeeping chores considerably. Since they have moved into their new electrically heated home she is enjoying a clean house with no fires to kindle, no coal to carry in, and no soot and ashes to mess up the place. Satisfied users such as this one in the Tennessee Valley have been the most influential factor in convincing home builders that electric heating and air conditioning, I may add, are essential in providing modern living.

REFERENCES

1. Heating, Ventilating, Air Conditioning Guide. American Society of Heating and Air Conditioning Engineers, New York, N. Y., 1956 edition.
2. Heat Pump Goes Industrial: Cuts Hatchery's Costs, J. D. Brown. *Electrical World*, New York, N. Y., vol. 145, Apr. 30, 1956, pp. 70-71.
3. Manual for Electric House Heating. NEMA, New York, N. Y., May 1956
4. Electric Heating in the Tennessee Valley—A Pattern for the Future, W. R. New. American Power Conference, Chicago, Ill., Mar. 1957.
5. Climatological Data. *National Summary*, U. S. Weather Bureau, Washington, D. C., vol. 16, no. 13, 1955.

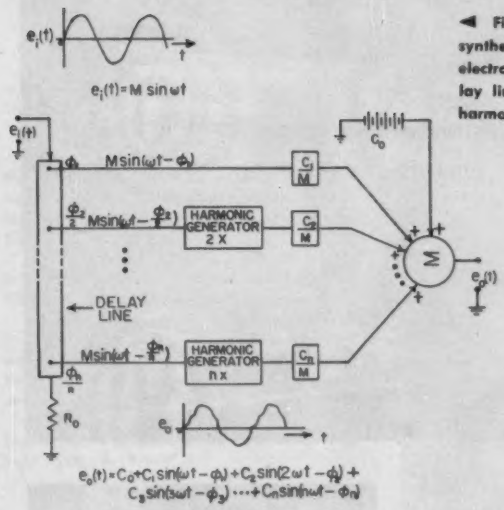
Space Age Spawns New Technology

With yesterday's "high-temperature" materials all but melting away under the intense heats of today's rocket engines, scientists are looking to new technology to produce the materials of tomorrow. Development engineers at National Carbon Company, Division of Union Carbide Corporation, New York, N. Y., find the company's 75-year experience in producing carbon and graphite for industry gives them a valuable start in attacking the temperature problems created by the space age. Here at one of the company's development laboratories, a technician watches through an observation port in a flame-test chamber as a new graphite-base material is put through its paces. Positioned in a jet of exhaust gases traveling at five times the speed of sound from an oxygen-kerosene flame (note characteristic diamond-shaped supersonic nodes), the conical specimen reaches a white heat of approximately 5,000 F in a matter of seconds. Conventional graphite erodes beyond tolerable limits in about 8 seconds, but National Carbon has already produced materials that hold dimensions ten times longer, and has its sights on even longer cycles—well beyond the normal operating requirements of rocket engine components.

Design of Function Generators

A. W. REVAY
ASSOCIATE MEMBER AIEE

D. J. FORD
ASSOCIATE MEMBER AIEE



◀ **Fig. 1. Fourier synthesizer using an electromagnetic delay line to shift the harmonics.**

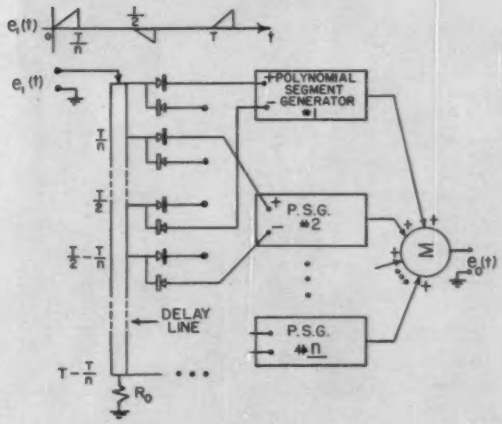


Fig. 2. A waveform approximation generator using *n* polynomial segment generators and delay line inverter network.

THE ANALOG-COMPUTER field is frequently concerned with the generation of periodic nonsinusoidal functions of time. At the present time, this waveform generation is frequently performed with biased diode networks, curve followers, and synchronous switches. The main purpose of this article is to give the theoretical design and analysis of nonsinusoidal function generators which utilize delay-type or short-time memory devices and certain nonlinear elements in their structure. The paper is meant to be exploratory, in a theoretical sense only, of a sizable number of different methods of waveform generation which utilize these circuit elements.

Two fundamentally different methods of generating waveforms are considered. The first, the "Delay-Line Fourier Synthesizer" (Fig. 1), delivers an output which is the sum of the first n terms of the Fourier Series expansion of the required nonsinusoidal waveform. The second method, the "Waveform Approximation Generator" (Fig. 2), delivers an output signal composed of n polynomial segments per period T of the input waveform.

The successful operation of the "Delay-Line Fourier Synthesizer" requires: first, that the Fourier Series expansion of the required waveform be known; and second, that n different harmonic generators be developed. The three types of harmonic generators studied are: the magnetic-core harmonic generator, the nonlinear-element harmonic generator, and the multiplier-type harmonic generator. Of these, the magnetic-core harmonic generator seems to offer the greatest promise. It utilizes the peaking characteristic of the presently available, square-loop magnetic cores, and exhibits a small physical size as well as an entirely passive structure. The principal disadvantage of the generator is the need for determining the mathematical form of the Fourier Series of the desired waveform.

The "Waveform Approximation Generator" of Fig. 2 utilizes n polynomial segment generators (PSG), each of which delivers an output polynomial function of time during a T/n time interval for a linear or ramp time-function input. A double-L passive network composed of linear and nonlinear resistors can be built to deliver each polynomial term except the constant term. This constant term in the general polynomial function may be formed by using a modified series output limiter circuit which contains one operational amplifier. By using a high-degree polynomial in each PSG unit, a relatively small number of such units would be needed for highly accurate waveform approximation. It is believed that the experimental "trial-and-error" adjustment of this "Waveform Approximation Generator" would be quite simple since each PSG unit acts independently of the remaining units.

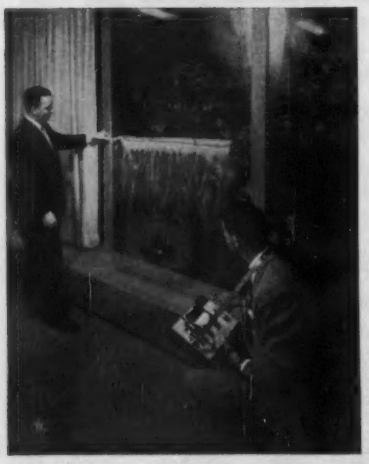
The high accuracy attainable in some of the designs may help to keep pace with the increasing demands for accuracy being currently placed upon the analog-computer industry.

Digest of paper 59-247, "The Design of Function Generators Using Short-Time Memory Devices and Nonlinear Elements," recommended by the AIEE Computing Devices Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y. Feb. 2-7, 1958. Published in AIEE *Communication and Electronics*, vol. 77, pt. I, May, 1958.

A. W. Revay is a lieutenant in the U. S. Air Force, Harlingen Air Force Base, Texas; D. J. Ford is with the University of Pittsburgh, Pittsburgh, Pa.

Pictorial Review

Test Facility for Central Air Conditioning



A ROOM simulating weather extremes and interior heat loads for demonstrating central air-conditioning systems in virtually any new or existing multistory building to owners, architects, consultants, or development engineers has been announced by Carrier Corporation, Systems Engineering Laboratory, Syracuse, N. Y. Temperature of air in room, its velocity, sound level, and distribution pattern at any point, as well as effects of radiation, can also be noted. Design theories for new air handling apparatus can be proved saving many man-hours. Demonstration module (*top left*) permits interested persons to see and feel what working in a new or remodeled office will be like. Sides are flexible and ceiling adjustable for duplicating exactly rooms in office buildings, hotels, or hospitals. Six different central systems plus radiant heating can be compared. A Weathermaster unit is installed above hung ceiling in the "hallway." Conditioned air is discharged into the room through a flush wall grille which is located over the door. Three different outlets for the five most commonly used central air-conditioning systems (*above right*) are demonstrated. Outside temperatures from 0 to 120 F can be created and interior heat loads caused by sun, lights, machines, and people simulated. Engineer is checking velocity of air from overhead diffuser. Picture window and intercom network permit large groups to follow tests or watch air-flow patterns using smoke bomb. "City waterfall" (*center left*) is seen in smoke test that shows downdraft from window on typical winter day when there is no air conditioning. Temperature outside glass is maintained below freezing. Engineer at right is operating electronic air meter. Under these conditions, cold air slides down inside surface of window and across floor at speeds up to 100 fpm. Curtain of air (*center right*) shows air-conditioning effect with invisible wall of air reversing downdraft and mixing with cool air before it can touch room occupants. Upward flow of air moves across ceiling and down opposite wall, providing draftless circulation at desired temperature. Elaborate electronic devices (*lower right*) can detect sound pressure levels anywhere in test room. Industry representatives report it the "most complete facility."

CC Systems Engineering Photos

ELECTRICAL ENGINEERING EDUCATION

AIEE in Duke University

THE STUDENT BRANCH OF AIEE at Duke University, Durham, N. C., was organized February 10, 1927. Present counselor for the Branch is J. L. Artley.

The Engineering Building *(right)*, completed in 1947, houses the Departments of Civil, Electrical, and Mechanical Engineering.

Most of Duke's newer buildings, such as the Engineering Building, located on roadways surrounding the crossed quadrangles of the West Campus, are Georgian and are constructed of red brick.

In Spring 1958, Duke was host to the AIEE District No. 4 Student Conference which was held April 16-19.

Engineering Education Yesterday, Today, and Tomorrow

W. J. CREAMER
MEMBER AIEE

IF A HIGH SCHOOL BOY were to ask any one of us how to come by an engineering education, I suppose we would immediately answer: "By attending a recognized College of Engineering." Now you, who are practicing engineers, and I, who have been a teacher of engineering for nearly 40 years, know this would be far from the complete answer. An engineering education is a jewel of many facets, the polishing of each of which requires different disciplines, some acquired in college, some elsewhere. It has been said that if you wish to educate a man you should begin with his grandfather; but if you wish to educate a man as an engineer it would seem that there is no beginning and no end. You take what you can find, you soften it up with a little heat, you hammer it into rough form in the forge, you temper it with the oil of precedence, you polish it with the abrasive of experience. Eventually, you will have an instrument which is serviceable for a time, and then, before you know it, the thing becomes obsolete and you have to begin all over again.

This is the pattern of engineering education, never complete, never fully satisfactory, never quite good enough for the novel task ahead; but still, providing the springboard for those who can leap, the elasticity for the rebound.

I am committed to speak chiefly about that facet of engineering education which we call academic; but perhaps I may be forgiven if at times I seem to venture beyond this natural limit.

Engineering Education Yesterday

In order that we may be in proper perspective, let me take you back to my first years of teaching, the 1920's. The electrical engineering curriculum of those days contained a substantial amount of physics, chemistry, mathematics, circuit analysis, and principles of rotating machinery. There were no frills, nothing too imaginative. Industry had been slogging along for many years, registering slow but persistent growth. Even World War I had not provided much in the way of new demands, although we had learned that it was possible to talk across the Atlantic by radio telephone, and had electrified a few railroads. Engineering education seemed to be doing a reasonably good job in preparing men for the type of professional work then available, and there was little criticism of the colleges at that time.

A few engineering educators, however, subjecting themselves to self-criticism, began to be genuinely worried about whether our engineering colleges were really doing an adequate job. A grant of half a million dollars was obtained from the Carnegie Corporation, and, in 1922, an elaborate survey of colleges offering engineering degrees was undertaken under the leadership of Prof. William Wickenden. This survey, which lasted 6 years, was largely made by means of the instrument known as the questionnaire, which had just come into full bloom as the flower of man's intelligence in that remote day. As I think back to the mass of data which I helped to compile at that time in connection with our own university, I am appalled at the scope of the work undertaken and carried through to the bitter end. Under the spur of a very energetic leader, hundreds and thousands of tabulations were made, showing all the variations in curricula in different institutions, how many colleges taught physics in the freshman year, how many in the sophomore year, how many credits in electrical engineering were required, how many in allied engineering subjects, how many electives, how many nontechnical credits; but as to how well these subjects

Essentially full text of an address delivered before the AIEE Maine Section, May 1958. Recommended for publication by the AIEE Educational Publications Committee.

W. J. Creamer is head of the Department of Electrical Engineering, University of Maine, Orono, Maine.

Electrical Engineering Education

were taught, or whether the time spent on them could be justified, not the slightest indication was obtained. Any semblance of critical appraisal was buried under an avalanche of inconsequential data. But the mammoth effort was complete in 1929 and the results published in two large volumes, each only slightly less in size than our well known "Standard Handbook for Electrical Engineers." And when all the words were said and the columns of figures added up, the final stupendous conclusion drawn was simply this: That there was nothing at all the matter with engineering education. So the two volumes were tucked away into a remote corner of some bookcase, the survey was quickly forgotten as a bad dream, and engineering education rolled on as though nothing had happened.

But it did roll on. Educators who had not been smothered by the Wickenden survey began to see the need for courses in electronics, and institution after institution introduced them. A similar situation developed with regard to network theory and to a lesser degree with electroacoustics. Gradually, a new look in electrical engineering was developing. Some colleges had enough courses in electrical communication to warrant establishing a division which could be called a communication option. All this happened in spite of older men who declared we must not specialize, and in spite of industry which said the same thing and then hired the very students who had done so in preference to those who had not.

Thus, we see a steady expansion of the scope of the courses offered in engineering colleges in the late '20s and early '30s, most of which followed on the heels of an industrial development which seemed to require familiarity on the part of the engineering graduate with new techniques. The dominance of 60-cycle theory was at an end. Telephone and radio circuitry were being exploited and a few clumsy demonstrations of television had already been made.

Then the great depression brought a large segment of industry to a stand-still. Students still flocked to the engineering schools but had to be content with low-level jobs after graduation. The failure to hire college graduates, even at a financial loss, some industries were later to regret. The evolution of engineering curricula still went on without fanfare, our best teachers experimenting with new teaching techniques as well as with new subject matter, but the pace was slower.

Industrial effort eventually began to pick up and then was sent surging forward by the second World War. The electronics people were in control with their new communication systems and microwave radar. Significantly, it was the physicist rather than the engineer who led in much of the development work of the time. Engineers seemed to lack the originality required to break through the natural barriers. Once the way was clear, however, they demonstrated their power of following through and producing in abundance.

Engineering Education Today

The war developments and those since World War II took a new trend. Just as the communication people freed us from the limits of 60-cycle theory, so the electronics people freed us from the limits of the sine wave and founded a whole new world of pulse techniques, with its heavy dependence on transient analysis. Today, we are learning to count in various new ways, to process physical data by machines, to study information transfer as a presently wasteful art capable of great economies.

New techniques call for new materials. We now have a host of new magnetic and dielectric materials developed by chemists, physicists, and metallurgists, with their promise of new instrumentalities for engineering progress. Superconductivity is being studied, the transistor is being improved, and intense effort is being devoted to the direct conversion of atomic to electric energy. The day is coming when terrifically strong electric and magnetic fields in conjunction with extremely high temperatures will permit the approach of atomic nuclei and by the fusion process produce electric energy without the wasteful steam cycle that is now being employed. In this process, the electrical engineer will have a prominent part.

The impact of these developments in our scientific world is being felt as a new influence in engineering education. Left to themselves, our engineering staffs of instruction will deal with these new trends as they have in the past by the evolutionary process of new courses and new techniques; but administrators, mistrusting the capabilities of those charged with instruction and impatient of the slow development process, have begun to bedevil the evolutionary process with revolutionary proposals. The so-called Grinter Report of 1953 is a case in point. This report, emanating from the Education Committee of Engineers' Council for Professional Development and the American Society for Engineering Education Committee on the Evaluation of Engineering Education, suggested the bifurcation of engineering education. One division, to be called "professional-general," would be concerned chiefly with training for production, operation, and management functions, while the other division, to be called "professional-scientific," would be concerned chiefly with training for research and development.

A storm of protest against this proposal was aroused, mainly by some engineering departments other than electrical; and the word "bifurcation" is a dirty word now in educational circles. The origin of the proposal, it seems, was largely in the professional groups of electrical engineers, which had already sensed the need for more training in mathematics and basic sciences, and had attempted to force this rugged diet down the throats of all the other engineering groups. The effort failed, without an attempt at just evaluation or compromise. And yet the idea of a more highly scientific training has been kept alive and implemented by the electrical engineering departments of certain progressive institutions which have gone pretty much "all out" for the scientific aspect of engineering education and have made drastic changes in their curricula. The problem seems to be simply this: Are engineers to be content to serve as manufacturers of and operating personnel for machines and facilities which other scientists have envisioned and designed, or are engineers themselves to become scientists responsible for the creation of the new technology that is being and must be thrust upon us?

Personally, I am in full agreement with those engineering educators who feel that the teaching of current engineering practice must be subordinated to the exercise of the disciplined approach and the rigorous analysis, and the cultivation of the imaginative solution. And yet I still find motivation to study in current engineering practice. I am obliged to believe, therefore, that undergraduate training should represent a compromise in these positions, and that graduate work should be expanded and emphasized as the training ground for research and development engineering. This does not imply a loss of rigor in undergraduate training; but rather the reverse, since it is on the undergraduate years that graduate disciplines must be built. I am certain that the state of unrest that now exists in engineering education is a healthy state, and that the self-analysis to which engineering educators are now subjecting themselves, is a far more productive thing than the sterile survey of the 1920's.

The work of the engineering educator today is complicated by a series of frustrations. We are trying to cope with a technology which is forging ahead at breakneck speed. We just get to know how to teach the fundamentals of a certain subject when the subject becomes outmoded and our teaching becomes pointless, or perhaps the subject develops so elaborately that the fundamentals we taught become wholly inadequate. And so we have to rack our brains to meet the new challenge.

Industry is continually crying for us to teach fundamentals, but fundamentals themselves change in importance, and what seems to be significant today may fade in importance in a period of 10 years. Industry would have us avoid specialization in this concentration on fundamentals, but it must be realized that it is the specialities that provide motivation and at the same time demonstrate how fundamentals are used. You cannot nurture a college student on nothing but abstraction. I believe we can never fully anticipate what the demands of our technology will be 10 or 20 years hence. We must rely on the ability of graduates to grow in intellectual stature after they have left our halls. The major concern then should be to cultivate the potentiality for such growth.

A second frustration which we encounter is the lack of proper high school preparation on the part of students. In no small measure, this deficiency must

be charged to the policy of our schools of education throughout the country which have spent most of their time in teaching *how* to teach, and very little in acquainting their students with the subject matter they should be required to teach. Hence, their graduates go out into the high schools and apply the elegantly refined principles to the teaching of mathematics without having the faintest idea of what mathematics really is or what it is used for. There is little comprehension of its beauty and its power. The result as well we know is not a happy one.

The same situation applies in English, our mother tongue, our best means of communicating ideas. Thus, when the poor freshman enters an engineering college, he is a young man lost in a wilderness, who has no means of communicating with the academic world and no mathematical ability as a navigator to make an intelligent approach to a technical education. His first year in college is largely spent in overcoming these deficiencies and, as a result, no real engineering can be offered to him. This is a shameful waste of valuable time which must be charged to a tolerant public which does not take enough interest in the education of its youth to challenge the existing program of secondary education with its emphasis on sports and trivialities.

Actually, the guilt of the secondary school rests far less in the realm of subject matter taught than in the realm of mental disciplines. Many high school boys who are college material are coasting along with little effort required of them and little incentive to do superior work. These are the boys who, attempting a college course in engineering and finding themselves unaccustomed to concentrated mental effort, are unable to meet the demands of the college classroom. They fail, not because of low mentality, but because a school system based on the cult of mediocrity and accepted by a complaisant public has failed them in its high duty of building mental stamina. Elementary and high school teachers are told by schools of education that they should not fail a student; the students must all pass. And parents are ever ready to pillory the teacher who has the courage to hand out deservedly low grades. Thus do educational standards wither on the bough.

But you and I know that there is such a thing as failure, for have we not all failed in some respect. We do not prepare our children for life unless we make them aware that failure does exist, and that it can be overcome not by wishful thinking but by persistent intellectual effort. If we shelter our youth from all experience of failure we do them wrong, for when they reach college they are poorly equipped to cope with the intellectual demands that will be made of them. Some of us have high hopes that progress will be made in this state through the continued consolidation of small high schools into larger units where better instruction may be provided. But this movement is often restricted by the small towns whose taxpayers would rather have their children taught basketball than trigonometry. It is a fine thing to take pride in a local enterprise, but if we ever needed a national standard it is now needed in secondary education. Let us dare to abandon the traditions and folklore which have served us so poorly.

A third frustration that all higher education encounters today is the lack of dignity in the teaching profession. In the early days of this republic, the preacher and the teacher were respected members of the community. But today our interest in intellect is at low ebb. We are the people who must be sold more goods whether we need them or not; so we spend annually $10 billion in advertising, a sum equal to the cost of all our primary and secondary education. We are the people who must be entertained; so we pay enormous salaries to our entertainers. We sit in a comfortable chair and watch for hours on our television screens endless displays of violence and the primitive emotions. Our highest salaries are gleaned in Hollywood, but the USSR's highest salary is paid to the President of the Soviet Academy of Sciences. Senior professors, research scientists, and top engineers in the USSR frequently are paid 6 to 10 times the average industrial wage, equivalent in this country to between $25,000 and $40,000 a year, and are held in the highest regard of any segment of the population. The counterpart of these people in our country are dignified by such names as "egg-heads" and "long-hairs" and are represented in cartoons standing before a blackboard, pointer in hand, with their mortar-board caps askew, and a vacant look on their faces.

It is time we realized that we are the people who must be educated to recognize *values*, intellectual as well as physical, before it is too late. The USSR, it would seem, has the present mastery of outer space; but the USSR has also mastered the problem of long distance d-c transmission of electric energy. Obviously, says Admiral Rickover, she has developed ". . . in record time, an educational system which produces exactly the sort of trained men and women her rulers need to achieve technological supremacy." The pity of it is that in this country we have the potentiality to outperform these people if our efforts could be organized to utilize the abilities we possess; and yet we fritter away our time, our energy, our talent on trivialities and on "social adjustment" to the present, when we very well know that the present will not be with us tomorrow. Sputnik brought home to us that behind the iron curtain great events in Soviet education have transpired, and that we have been leading a sheltered life behind our own curtain of complacence and have failed to appraise our own educational system for what it largely is: *a wastefully inefficient, purposeless effort, molding our youth into a mass of mediocrity with little attention to the cultivation of excellence.* We have developed excellence, but in a haphazard, random manner. This may be freedom, but it is a freedom which is in jeopardy today. It has been hopefully said that "the ultimate supremacy of free men will not be found in outer space; it will be found in the inner conscience." This may be true, but it could well be a supremacy bought with blood, a supremacy we should wish to win by other means.

Electrical Engineering Education

Desperately do we need inspired and inspiring teachers in schools and colleges, given encouragement in their efforts for self-development, respected and honored for their devotion to their tasks, well paid for their high endeavor in revealing to our young people the glory of creative minds and the challenge of excellence.

Thus, we engineering educators do battle against not inconsiderable odds. The speed of technological development is met by a continual reshuffling of course content in the effort to weed out the obsolescent and to teach the basic material more efficiently, thus making a place for the new. The inadequate high school preparation we shudder at and try to find a little time to overcome, and soon we shall be forced to take more drastic measures. To enhance the dignity of our calling we can do little; this must come from without. To encourage a type of professional study we have only the bad weapon of low grades. With the speed-up of industrial development must come the speed-up of technical education. The race is to the swift. Repetition and duplication is a luxury which we can no longer afford. But I shall always believe that our highest duty is to search out the individual student who hungers for learning, who can be taught to appraise and evaluate, and to cultivate devotion to creative thought and creative works.

The relation of industry to engineering education cannot be ignored. We are educating personnel for industry and its needs are our concern. It is our endeavor here to keep in touch with our graduates who have entered engineering organizations and learn from them how well their training has fitted them for their work and where it has been shown to be inadequate. Thus does the individual alumnus help us to keep in touch with the current requirements of industry, and chart a course for the future.

Industry as well as education has its spokesmen who do not always appraise its needs correctly. About 10 years ago, the U.S. Bureau of Labor Statistics in its "Occupational Outlook Handbook" intimated the colleges were graduating too many engineers. This statement was re-echoed by a prominent engineering employment executive and, as a result, many high school graduates were discouraged from entering our technical colleges. Last year, that same executive bemoaned the fact that too few engineers were being graduated. If the engineering college graduate must depend on the current industrial economy for job opportunity, then industry must not complain of the lack of graduates in other years; for students are not encouraged to embark on a rigorous four-year training period with unemployment awaiting them at its termination. Industry must do away with this variability of demand; it must sta-

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bilize its employment of graduates from year to year so that educators and students alike will have assurance of opportunity. Does industry indeed show such complete lack of imagination that it cannot find profitable work for eager young men to do even in times of economic depression? Where is the vaunted efficiency of an organization that lets talent go to waste? Will this policy pay the dividends of the future?

Fortunately, a diffusion of opportunity has taken place in the electrical engineering employment situation. Graduates are no longer restricted to jobs with a few large companies, but often find positions available in many small industries whose effort is not mainly in the electrical field at all. This is a healthy situation and one which we may hope is due for future expansion. The other factor to note is the greater availability of college trained men for electric utilities, which for so many years have had difficulty in getting enough men to cope with the problems resulting from the phenomenal growth in demand for electrical energy. Will this industry take advantage of the opportunity to attract high-caliber college graduates with an adequately competitive wage, or will it still look about for the low-ranking student who will accept a low wage and provide a mediocre service? This is a question which must be answered if our engineering educators are to know where they stand on the matter of engineering employment.

Engineering Education Tomorrow

Let me say a few words about the flood of students that is supposed to overwhelm the colleges in a few years because the birth rate began to soar in 1942.

If the engineering colleges are to be flooded with students in the years to come, there may be some drastic changes in our instruction. Prof. Bibber of Union College, writing in the *Bridge* of Eta Kappa Nu (Winter 1957 issue) has pointed out that there will be larger classes, simultaneous instruction in several rooms by one instructor using closed-circuit television, objective type examinations of the true-false or multiple choice types which can be graded by machines, a simplified laboratory instruction that searches for basic principles rather than for performance characteristics of machines, and a general change in the student–instructor relationship to put the student more "on-his-own." He points out too that "young men who are not highly motivated—such as those who finally get through our colleges today by virtue of the personal interest and even worry of faculty members—are not likely to get far under this new regime of responsibility for their own education."

Let me add my observations on this problem of flooding. I have been through one flood—the flood of GI's at the end of World War II. We did very well with only slight modification of standard procedures, but we knew the situation was a temporary one. This time it may have more sustained power behind it, but I would point out that the high schools have for a long time been subject to this deluge. This example, with its frequent degradation of standards, we have staring us in the face; and it points the answer for us. There is but one simple and logical solution and that is to raise our educational standards. I think we should welcome the opportunity for a more careful selection of our material and a more rigorous test of survival. In this way, our product will be up-graded, the market for engineering talent will not be flooded with a low-quality product, and the financial rewards for engineering effort will be increased rather than diminished. In fact, the problem facing this country today is a far greater one than that of upgrading our scientists and engineers. It is rather the problem of upgrading the people as a whole through an educational system that strives for excellence instead of mass mediocrity.

Over the space of the years that I have been teaching engineering, I think I have discovered some changes in the material we work with. First, I think our students today are on the average more intelligent than they were 40 years ago. Second, I think they have less inclination to use their intelligence. Third, I think engineering education, at least for electrical engineers, is much more demanding than it was when I began teaching and, hence, calls for greater student effort. Fourth, I think the best of our product is of far higher quality than it used to be; in testimony of which I can cite the performance of recent alumni in graduate schools as well as in industry.

As we look hopefully into the future, we are convinced that we must find freshmen students properly equipped in mathematics and English before they arrive on the campus, so that their four years here may be spent on the engineering studies which have grown so much in scope and importance. The engineering college must cease teaching technicians, and concentrate on preparing young men for leadership in research and development and management. This will be done in a variety of ways in a variety of institutions, but always with the objective of developing creative ability and the power of critical appraisal. There will be need for a better appreciation of scientific principles in all divisions of engineering and a fuller understanding of the engineer's relationships to the social and political life of the community and the nation.

Industry has an obligation to use these engineering graduates wisely. College is but a four-year segment of experience in the lifetime of a man, and we must not expect too much of that brief period; but, on the other hand, as it is perhaps the most important four-year span in a man's life, every effort should be made to utilize it most effectively. In four years of college, even the poorest graduate will have learned much that can be turned to advantage; and if a man is in the upper half of this graduating class I would be willing to gamble that he has something creative to give to the engineering profession. You must treat him as an intelligent worker who truly must serve an apprenticeship but not in menial tasks. The chances are he knows more mathematics than you do, but you don't have to be afraid he will take your job away from you. Rather the fear is that if you do *not* associate yourselves with these young men you will stagnate and the job will grow away from you. As we lift others we lift ourselves. These young, naive graduates are hungry for opportunity, and the industry that passes them by will soon be in a sorry state.

I ask you, would you not like to be hiring such qualified men over the next 10 or 15 years? Would you not find it stimulating to associate with them and assist in assimilating them into your organization, to see to it that their environment was conducive to their rapid growth, and then to find that their contribution had really brought you and your organization to a higher level of service in this technological world? Can you not in all sincerity believe in this and encourage us to develop this excellence, confident that it will become the life blood of technical achievement in the years to come?

EMC Reports on 1958 Engineering Graduates

Close to 80% of the estimated 33,000 engineering graduates of the 1958 class had completed plans for post-graduation activities, a month before they were scheduled to leave campuses. This was revealed in a recently completed survey of the Engineering Manpower Commission (EMC) of Engineers Joint Council.

Despite generally unfavorable economic conditions in the country, the demand for new engineering graduates continues high as revealed by other facts in the report: 59% had accepted employment; 11.5% were considering firm job offers; 10% were entering graduate studies; 9.5% were entering military service; and the balance—or only 10%—had no definite plans or did not have offers for employment by late May.

These results are based on information provided by deans of engineering of over 100 colleges in the country, concerning plans of nearly 16,000 engineering graduates. The study indicated a much less favorable employment climate for other graduates, with 25% of business administration graduates and 30% of liberal arts graduates uncommitted and without job offers.

The full report may be obtained on request from: Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

A Watt-Hour Meter Demonstrator

A. D. MOORE
FELLOW AIEE

THESE ARE THE DAYS when we are expected to originate new teaching aids, and devices to make college and high school students more science-minded. The simple watt-hour meter demonstrator described in this article meets both needs. It can be so readily constructed and so satisfactorily operated, that it will appeal to teachers and students alike, at any level.

The watt-hour meter has no competitor. Electric energy going to the home, the commercial establishment, and the industrial plant, is all measured by this unique and highly developed device. It is the "cash register" of the electrical utility business. It deserves more attention than it gets in the typical electrical engineering curriculum. This writer has long been telling his students that the principles of the watt-hour meter, together with the implications of its use, permit the claim that it offers a more complete review of the nonelectronics part of the electrical engineering curriculum than does any other piece of electric apparatus.

Electrical engineering instructors wishing to teach some watt-hour meter theory will find that illustrative problems based on an actual meter are difficult to devise. But the demonstrator described here can be built, and very realistic problems can be based on it.

Any high school or college student can build his own demonstrator. The demonstrator is bristling with physical principles, and it easily lends itself to their demonstration. This article will be kept on a nontechnical level. Thus, instead of scaring the beginner, it is hoped to coax him into starting a project of his own, in which he can have a lot of fun learning some rather important things.

The Watt-Hour Meter

The meter's objective is to measure energy, or watt hours. Its aluminum disk must have a speed proportional to the watts utilized by the load. To achieve this, the meter must meet two requirements: (1) it must have a driving torque proportional to the watts, and (2) it must have a drag or damping torque proportional to the speed.

Requirement 1 is met by the arrangement of coils on the laminated iron core, in a real meter. A "potential" flux, set up by the potential coil across the line, is passed through the disk. If the meter is to operate correctly at any power factor, this flux must lag behind the line voltage by 90 degrees, and this is arranged for in any meter. There is also a "series" flux passing through the disk, set up by the series coils carrying the load current; it is in phase with the current. Thus, the two fluxes are 90 degrees out of phase if the load is purely resistive (load current and voltage being then in phase). A-c eddy currents are set up in the disk surrounding each flux; each set of eddy currents reacts with the other flux, forces are produced, and thus the drive torque is produced.

Requirement 2 is met, in the real meter, by use of damping magnets. Alnico magnets, one or more, are arranged so that their steady flux passes through the disk. If no movement occurs, no force is developed. When the disk rotates, it moves through this damping flux, and those special eddy currents known as Foucault currents, are set up. The emf induced is proportional to speed, and so are the current strengths. The currents interact with the damping flux itself, and thus produce a drag or damping torque proportional to speed. In the demonstrator, we will use a different damping principle at first.

Demonstrator Parts

In describing these parts (Fig. 1), the first thing to be said is that there is nothing critical about any of the dimensions. The writer built his demonstrator out of materials which happened to be at hand, and using such skills and techniques as were part of his experience. Other builders will do likewise. The design is extremely flexible. We can almost say—build one of these to your own taste, and it will work.

The 9 x 12 inch plate is plate glass, a little over 0.2 inch thick. Flat window glass could be used. The ring on it is Plastelin (registered trade mark), or plastic modeling compound (used in kindergartens). The ring has a section of ¼ x ¼ inch, and its internal diameter is 9 inches. To make it, some Plastelin was rolled out, and strips were cut from it. These strips were bent around on the plate, joined end to end, and stuck to the plate.

The aluminum disk now resting on the plate, is 8 inches in diameter and 0.05 inch thick. Arts and crafts stores carry such disks for etching, or to be hammered into trays. If the disk as bought is not quite flat, it can be well flattened by bending it by hand.

Behind the plate are four cylinders of heavy wrapping paper, taped, and stiffened with varnish or Krylon (registered trade mark) spray. They are about four inches high. Wood or plaster posts would serve equally well.

The two drive coils shown are two-layer coils wound by hand around polyethylene bottles. In use, the bottles are inverted, resting on a plaster foot. The screw cap of a bottle was cast into the foot. Thus, a bottle could be unscrewed and filled with iron particles to increase the flux.

These coils were soon replaced by better coils, now to be described. Each coil was wound by hand, two layers of No. 17 cotton-covered enamel magnet wire, on pieces cut from a heavy mailing tube. The tube length is about 4 inches. A coil, slightly shorter, has 62 turns per layer, and a mean diameter of 1.84 inches. The coils were heavily soaked with Glyptal, an electrical insulating varnish. These coils will take 4 amperes indefinitely, and 10 amperes or more, for short periods. Data given later were taken with these better coils.

It is a simple matter to put bottoms in

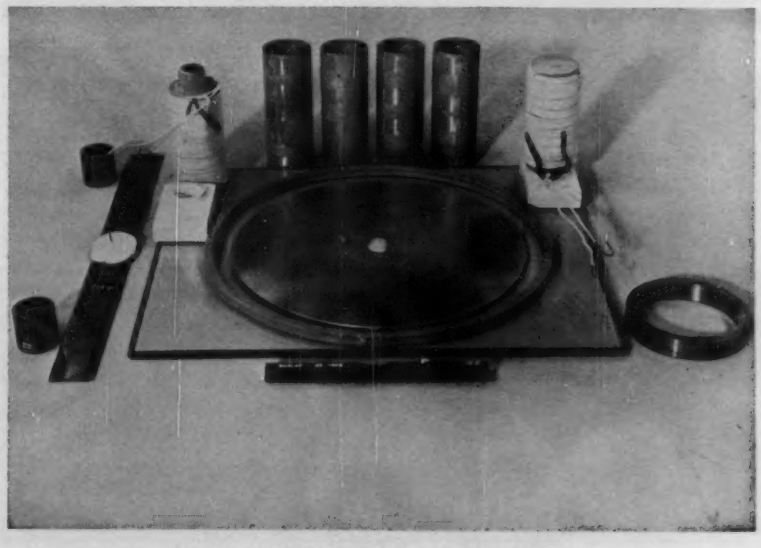

Fig. 1. Watt-hour meter demonstrator parts.

A special article recommended by the AIEE Educational Publications Committee.

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Electrical Engineering Education

these coils. Just "borrow" a little dental stone plaster from your dentist. Mix it with water, set the coil on a glass plate, and drop enough plaster down inside so that when jiggled down, the plaster is about 1/8 inch thick. After it sets, wet it to slip it off the plate.

For a centering bearing, the little plaster mound seen at the disk center was formed on the glass plate, with a bearing hole molded into it by use of a piece of wire. Make the hole deep enough to keep the bearing pin from touching the bottom of the hole. When the plaster sets, wet it to get it loose. After drying, the mound is stuck to the disk center with double-face adhesive material.

At the left of the plate is a brass piece, 1 inch x 12 inches x 1/16 inch thick. A paper clip was opened and cut so that it rested on the middle of the piece, with one end sticking straight up. Plaster poured over the resting part of the clip, and out over the edges of the piece, securely fixed the bearing pin to the piece. When the piece is inverted, the clip wire becomes a pin, to stick down into the plaster mound's hole. Also shown are two posts, 1 inch high. The brass piece and the posts could be replaced by wood or plaster. This was a bearing made by a man in a hurry. Anyone can think up better bearings.

In front of the plate is a small level, used to level the plate.

Damping and Supporting the Disk with Water. A large, heavy disk was desired, to be seen well at a distance. But a heavy disk would call for a rugged bearing with too much friction, or a delicate bearing too easily damaged. The solution included the idea of using surface tension to float the disk. At one stroke, the bearing problem was eliminated, and damping was obtained by fluid friction. The bearing described is merely a centering bearing. The side forces on such a bearing are extremely small.

Fluid friction or "viscous damping" for instruments is, of course, an old idea. We could use an aluminum pie pan, floating in the ordinary way to make a demonstrator without using surface tension, but floating the disk with the help of surface tension makes the demonstrator that much more interesting.

Demonstrator Assembled

Ready for action, the demonstrator is shown in Fig. 2. First, 4 ounces of water were poured within the ring, the plate having already been levelled. The disk edge and nearby surfaces have been lightly greased with silicone stopcock grease to make it water repellent. Before greasing, any roughness of the edge was smoothed off—otherwise the disk might sometimes refuse to float. The disk was then placed on the water with one side lowered first, then the opposite side gently lowered. This was to avoid trapping air bubbles underneath. At low speeds, bubbles will stop the disk.

Disk Supporting Forces. This disk weighs 111 grams or almost ¼ pound. It depresses the water, causing the water to bulge up all around it. The surface of the meniscus around the disk curves in and down, being almost vertical where it touches the rim. At first, it seems that surface tension is doing a miraculous job, to hold up this heavy disk. However, computation shows that surface tension accounts for only about 4% of the lifting force. Hydrostatic pressure accounts for the remainder. The main function of surface tension is to hold the raised water, keep it from encroaching on the disk surface, and enable the water to pile up enough head to exert nearly all of the lift force.

When one sees the floating disk merrily spinning on the water, the effect is indeed striking.

Power Supply. The leads to coil terminals are seen at the left rear of Fig. 2. If the coils get a few amperes, with the currents out of phase by a considerable angle, there will be action. To simulate watt-hour meter performance when its metered load is resistive, we should have coil currents 90 degrees out of phase. This demonstrator is powered from the normal supply: 115-volt, 60-cycle. A variable resistor is in series with one coil. A 100 microfarad capacitor, varied in steps, is in series with the other. The voltage drop over the coils is very low. Therefore, the currents that flow are very close to being 90 degrees out of phase.

Coil current needs can be changed at will, by going to a different wire size. For example, if No. 23 wire is used instead of No. 17, wire cross section is ¼ as much; the coil is given 4 times as many turns; and, at ¼ the previous current, a coil will produce the same flux, and have the same heating as before. Thus, coil modifications can be made at will, to suit the demonstrator to such Variacs (registered trade mark) or rheostats, and capacitors or inductors, as happen to be available.

Operation

Let the drive coils be placed together as in Fig. 2, at a position about ⅛ of the way from disk edge to the center. With about 4 amperes in each coil, a water film thickness of about 0.05 inch under the disk, and with the top turns of the coils about ¼ inch below the bottom of the plate, the speed is about 3.7 rpm.

Sensitivity. With fluid support, the disk is extremely sensitive to small driving forces. It is illuminating to note that when driven as just described, the power used to turn the disk is of the order of one thousandth of a horsepower. And, if the currents are reduced to give a speed of 1% of the aforementioned speed, it takes about one tenth of one millionth of a horsepower to drive the disk.

Accuracy. Let the current of one coil be fixed, while the other current is changed from low values, to 8 or 10 amperes. A straight-line calibration curve will result: speed is proportional to the varying current. This corresponds, in the watt-hour meter, to holding line voltages constant (therefore, potential flux constant) while varying the load current.

Fluid Damping. The fluid damping or drag torque, is largely caused by shear forces in the water film between disk and plate. There is some additional shear force contributed by water in shear outside of the rim of the disk, but this is the smaller part of it. Therefore, if the film is made uniform, and is accurately measured in some manner; if water temperature is taken, in order to derive the viscosity; and if an integration is performed to obtain the damping torque due to fluid friction, then the drive torque, which is equal to it, can be closely found.

Water can be added or withdrawn with a syringe, during operation. With the film thickness under shear thus changed, corresponding changes in disk speeds are nicely demonstrated.

Viscosimeter. The demonstrator, among other things, is inherently a viscosimeter. For example, when the water was replaced by diluted corn syrup (100 parts of syrup to 60 parts of water), the speed, for the same currents, was 1/30 as much. Thus,

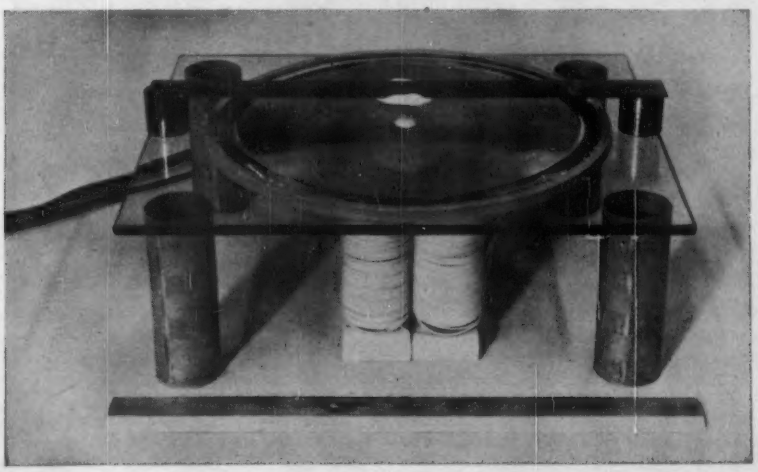

Fig. 2. Demonstrator assembled for action. The disk floats on water.

the syrup mixture had 30 times the viscosity of water.

Very Low Speeds. At low currents, the demonstrator will operate at speeds of one revolution per hour or less, where movement is barely perceptible.

Coil Positions. Coil position radii, and intercoil spacings, will affect the drive torque greatly.

With the coils together and at equal radii, let them be moved inward from outside of the disk, to where they finally straddle the center. A torque curve will result (as indicated by disk speed) which will have a maximum value. Watt-hour meters are, of course, designed to take advantage of this fact, with the fluxes positioned to give maximum torque.

If the two coils are placed, for example, as in Fig. 2, and one is moved away from the other while keeping its radial position unchanged, the torque rapidly falls off.

Another demonstration: starting as in Fig. 2, push the pair of coils across to the diametrically opposite position: the disk reverses.

Still another: starting as before, take one coil out, invert it, and hold it above the disk over its previous position: the disk reverses.

Using Iron for Higher Speeds. Anyone playing with a demonstrator will surely want to speed it up. It can be done. Filling the coils with hard cast iron shot increased the speed about 3.5 times. This shot was roughly spherical, and approximately 0.02 inch in diameter. Such shot is made for use with an air blast, to clean castings, and for shot-peening. Malleabilized cast iron shot, having higher permeability, raised the speed to about six times the original speed.

Disk Thickness. If a disk of half the thickness is obtained, and operated with the same water film thickness, it would, with the same coil currents, turn half as fast. The resistances of all eddy current paths would have doubled; eddy strengths would be halved; and, thus, driving torques would be halved.

The general effect of such a change can readily be shown by replacing the disk with one of the very thin aluminum pie plates, of the kind in which pies now come to the home. Its movement, relatively, will be very slow. No center bearing will be needed for this brief demonstration. (Note: if fluid damping were completely replaced by magnetic damping (to be described), the foregoing argument about thickness effect on speed, does not hold: the speed would remain independent of disk thickness!)

Magnetic Damping: Foucault Currents. Our millions of watt-hour meters all have their damping or drag torque produced by movement of the disk through the fixed flux of a permanent magnet (one or more). All of the millions of speedometers in cars and trucks operate on the effect of Foucault currents causing magnetic drag. The indexes of only a few books will include the name Foucault. Thus, our teachers and writers may welcome a chance to become familiar with the principles involved, by working with a demonstrator. If they do, these phenomena may be less widely ignored hereafter.

The Speedometer. The speedometer principle is easily demonstrated—remove the coils; make one-way passes close to and across the disk at one side, with a magnet; sweep the magnet across, lift it on the return, sweep it across again, and repeat—and the disk will begin to follow.

If a vertical bar magnet is placed under the plate and moved by hand to rotate around the center, the disk will follow at its own lesser speed, the speed ratio being constant for a given set of conditions.

In the actual speedometer, an aluminum cup tries to follow the magnet which is turned by the car movement, but is restrained by a spring. The deflection is inherently a measure of the fact that the drag torque is proportional to the speed. Of course, it is actually calibrated in terms of miles per hour.

Using a Magnet to Get Zero Setting. In some experiments, a magnet will be needed to bring the stationary disk's marker precisely to the scale zero. It can be waved there, with the magnet. Simply make slight passes at the disk with a magnet, one way or the other, and the disk is quietly moved by slight amounts without touching it.

Magnetic Damping for the Demonstrator. Suppose an Alnico magnet of the U-type, with a bulk of a cubic inch or more, is held so that its pole faces nearly touch the top of the rotating disk. If the magnet is strong enough, damping by the magnet will greatly reduce the disk speed: nearly all the damping is then magnetic, and little of it is fluid damping.

Fig. 3 shows such a magnet, rigged by clamping it to one side of a wooden bar, the weight of the magnet being counterbalanced by the lump of modeling clay stuck onto the far end of the clamp.

Moving the magnet radially will vary the speed. Thus, an experiment can be run to find magnet position to give maximum damping torque.

Driving Flux Damping. The drive fluxes are alternating, and each flux sets up alternating eddy currents around itself, in a pattern of eccentric circles. These drive the disk by virtue of each set of currents interacting with the other flux. These currents do not damp the disk.

Further, to bring out the next point, let us recall that with no drive coils in use, a bar magnet whirled around under the disk will make it rotate; also if we fix the magnet, it will cause magnetic drag or damping when the disk is driven by the coils. Now, think of replacing the bar magnet with a coil carrying d-c current, and having constant flux; such a coil alone would turn the disk, if carried around the center as we carried the bar magnet. And, if fixed, its steady flux would damp the disk when the disk is turned.

This suggests that if all but one of the a-c drive coils is removed and carried around the center continuously, it may set up a-c Foucault currents and start the disk turning. It will! A trial readily shows a small effect. Therefore, we must admit that when the demonstrator is in normal operation, with fluid damping, the a-c fluxes do contribute a little to damping. The a-c fluxes in the demonstrator are very weak, and their damping effect is very small. But in the watt-hour meter, the series flux becomes large enough at heavy loads to introduce serious error. In recent years, this "overload droop" error has been almost entirely overcome by a very simple but ingenious means: using magnetic saturation in a certain way to compensate for the error.

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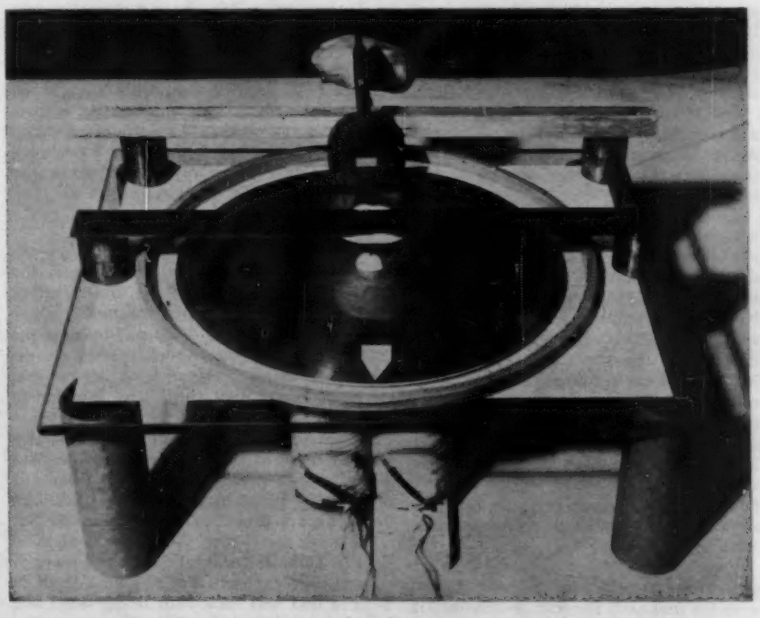

Fig. 3. The demonstrator in use, with magnetic damping. A pointer and scale are shown.

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Scale. A scale for observing disk movements is easily applied. An 8-inch circle is drawn on paper, with the circumference divided into 100 units. The graduations are marked outward. This is taped to the under side of the plate, so that one can look down through the water surrounding the disk and see the marks. A bit of paper dropped on the disk near the edge serves as a disk marker as seen in Fig. 3.

Exponential Change of Speed. Heretofore, we have considered only constant-speed conditions. Next, it is recognized that when power is suddenly applied, the disk cannot start from rest and instantly achieve final speed; and if running when the power is cut off, it cannot instantly stop. There exists here in rotational form, the same kind of a case that obtains when a mass is started with a constant force, but is retarded by a force proportional to the speed (it accelerates); or when a mass in motion has the driving force removed, and it is still retarded by force proportional to velocity (it decelerates).

It can be shown that under ideal conditions, the speed changes exponentially. In acceleration, if the first time interval T permits the speed to achieve P per cent of final speed, then in the next equal interval T, the speed will change P per cent of the speed change remaining to be made, and so on. Deceleration takes place similarly.

Acceleration. Acceleration can be nicely studied when using fluid damping only to get the greatest action. Starting at rest, turn on the currents, and time the first revolution, the second, and so on; or, equal parts of a revolution can be timed. If things happen too fast to catch the times all in one run, time the first revolution on the first try. Then start over again, take the time for two revolutions; and so on.

Deceleration or Coasting. This is studied after running at constant speed by suddenly cutting off the currents and observing disk positions as the disk coasts to a standstill.

An interesting study is developed by first letting the disk coast to rest without timing it in order to find the total angle units through which it will turn for the particular speed used. Suppose it is 100 units. Now put temporary markers on the scale at 50, 75, 87.5, etc., units from zero. This divides the coasting units into the first half, half of the remaining half, etc. Then energize to obtain the same particular speed as before, and cut off power as the disk marker passes zero. The intervals as laid out should display equal time intervals. They should, that is, provided the fluid damping behaves perfectly and gives a retarding torque proportional to speed while speed is changing.

However, perfection is not to be expected, because inertia of water moving with the disk adds its effect to disk inertia. The water outside the disk, in particular, will lag in getting into motion; and, again, it will have a lag causing overshooting, when deceleration occurs. Therefore, the time intervals mentioned may not check perfectly.

Short-Time Loads: Fluid Damping. Suppose coil currents are adjusted to give one revolution in 10 seconds. Here is an experiment to try: start from rest, connect to obtain the currents for 10 seconds, cut off the currents, and let the disk coast to rest. The disk is accelerating for the on-current time, then coasting afterward. Would one expect the disk to have turned through precisely one revolution? A watt-hour meter should do just that, for one revolution properly represents the energy that would flow.

However, as brought out previously, the outer water lag in fluid damping results in an imperfection. In one such experiment, the short-time movement was about 20% higher than would have been expected.

Watt-Hour Meter Plays Fair

The demonstrator with fluid damping overregistered. A commercial meter, however, is equipped with magnetic damping, which faithfully gives a damping torque proportional to speed under any conditions. It can be proved that with this "perfect" damping, the failure of the disk to come up to speed initially is exactly made up for by coasting when the load is cut off. There is no meter error.

The demonstrator will likewise perform correctly, if nearly all damping is magnetic.

Canned Motor Demonstration

The canned-rotor motor, so-called, has the stator and rotor separated not only by the air gap, but also by a thin metal sleeve placed in the gap. Thus, the rotor can be sealed within a fluid pumping or circulating system, as when radioactive fluids must be handled without having seals that may leak.

With the demonstrator running, one can slip a thin aluminum sheet under the plate and over the coil tops. Only a slight reduction in speed will be noted. If the sheet were quite thick, eddy currents induced in it would block more of the flux; but a thin sheet, preferably of high-resistance material, has little effect.

Demonstrator as Shaded-Pole Motor

With the two drive coils in use, the demonstrator is really an eddy current motor. An even simpler a-c motor which gets along on one drive coil only, is the "shade-pole" motor. Such motors are extremely simple, rugged, and inexpensive. They are widely used. Any number of little gadgets are run by these motors.

Let the demonstrator run normally, then remove a coil. The disk stops. But pick up a piece of copper or aluminum or brass plate, maybe ⅛ inch thick, and perhaps a couple of inches each way (or a heavy metal ring, shown at the right in Fig. 1), hold it near the disk, and more or less over the coil, but to one side of it. The disk will turn. Shift to the other side of the coil, and the disk will reverse. You now have a shaded-pole motor. What happens is that some of the coil's flux goes through the plate or ring, and induces voltage in it. The a-c currents flow around the plate, these lagging somewhat behind the induced voltage. The currents set up a flux which is out of phase with the coil's flux. If the ring is held somewhat to one side, then its flux becomes the second of two drive fluxes, and a torque is produced.

WARNING: If an overhead brass piece is used to hold the center bearing pin, it may innocently act as a shading member when the coil gets too close to it. This piece should be nonmetallic.

Using a Coil as the Shading Member. With the two coils placed at the front (near the operator) let the left-hand coil carry a-c current, while the right-hand coil is short circuited. The disk will rotate clockwise. Remove the "short," leaving the right-hand coil open, and the disk stops, provided the coils are empty. But, if they are filled with iron shot, the disk will rotate very slowly the other way.

The writer freely admits that when his demonstrator played this foul trick on him, he was sorely puzzled. No light dawned until he stopped thinking about eddy currents in the shot, and began thinking about hysteresis effects.

Circulation of Mercury

If the disk and water are removed, a pound of mercury can be poured into the plate inside the ring. It will form a pool of perhaps 8 square inches in area. Now let the two drive coils (filled with iron shot to get full effect) be placed together, and somewhat under the mercury. Very soon, a fairly rapid circulation pattern will be set up in the mercury.

This phenomenon bears on the principles of the electromagnetic pumps now used to move liquid metals in nuclear power reactors.

WARNING: Mercury is insidious stuff. It is not widely recognized that a serious hazard can develop if it is spilled and allowed to hide under a steam radiator in a small, poorly ventilated room. A physicist known to the writer, working under such conditions, became almost completely paralyzed from breathing the vapor, before the mercury poisoning diagnosis was made. Fortunately, he made a good recovery.

Inverting Demonstrator Design

The demonstrator described has the advantage of making the disk accessible, and placing it in full view. However, the disk does cover up the coils, and onlookers may not always be sure of coil locations as coils are moved around.

The design can be inverted by placing the plate, with its ring, water pool, and disk, directly on the table. A second glass plate is then rested directly on the ring, and the coils are set on this top plate. Coil positions are always evident.

Disk centering can now be done magnetically. A small piece of iron is fastened to the disk center with double-face adhesive. A small U-shaped Alnico magnet is set on the top plate. The magnet will draw the iron piece to a position under the magnet center, and pretty closely hold it there during operation.

Conclusion

The demonstrator is so versatile, and so adaptable to the direct demonstration of numerous physical principles, that it is a first-class teaching aid. This has already been proved in the writer's classes.

The watt-hour meter demonstrator is a fascinating thing to operate, and it invariably attracts the attention of all who see it. It is so easily put together that one may hope to have it appear, not only in classrooms and laboratories, but also on display in annual Open Houses.

Reference

1. Eddy Currents in Disks: Driving and Damping Forces and Torques, A. D. Moore. AIEE *Transactions*, vol. 66, 1947, pp. 1-11.

2. Bibliography on Watt-Hour Meters (S100), AIEE, New York, N.Y.

Electrical Engineering Education

Simplicity in 3-Phase System Circuit Conventions and Concepts

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Part I

IN THE ANALYSIS of electric circuits, certain conventions are necessary, or at least desirable, to facilitate understanding and checking. Actually, also, the formulation of basic laws depends upon the conventions used, so that in any review of the subject, both conventions and basic concepts can well be treated together. Obviously, understanding is increased and chances for error and misunderstanding are reduced if the conventions used in all areas of circuit analysis are the simplest, most logical, and most consistent. This analysis is particularly concerned with 3-phase systems.

Reference Direction and Polarity

In any general circuit analysis using the loop method, it is generally agreed that the first convention to establish is the reference direction of current in each closed loop. This, of course, is not a direction in space, but a sense of direction around the loop. That is, if the loop lies in a plane, the reference direction is clockwise or counterclockwise around the loop. This reference direction is usually denoted by an arrow placed on the circuit diagram in such a way that the loop to which it applies is clearly evident and the symbol which identifies the current is usually placed adjacent to the arrow. In this system, each current is usually denoted by i with an appropriate subscript to indicate which current is meant. The subscript ordinarily carries no significance regarding the direction of the current, that being the function of the arrow.

When the current is in the reference or arrow direction, it is positive and is represented by a positive number indicating its instantaneous magnitude. When the current is in the opposite direction, obviously it is then negative and its magnitude is represented by a negative number.

If, for purposes of analysis, a circuit loop is cut by a simple surface more or less at right angles, there will be two points of intersection, which may be called terminals. It is desirable to identify the terminals from the standpoint of voltage measurement and to select one as the reference terminal with respect to which voltage is measured. The other terminal should then be specially identified to indicate that its voltage or potential is specified with relation to that of the reference terminal.[1] There is no unanimous agreement as to how this should be done. A plus sign or a dot near the nonreference terminal is frequently used. Other authors use an arrow directed from one terminal to the other, but there is no unanimous agreement as to which way the arrow should be directed, some directing it toward the nonreference terminal to show the direction of voltage rise and others toward the reference terminal to show the direction of voltage drop. To avoid any complications on this score, the nonreference terminal will herein be called the "positive" terminal, and will be indicated by an adjacent plus sign. This will then give the arrangement shown in Fig. 1.

There is a tendency in elementary texts to call the quantity which would be measured by a voltmeter connected from terminal a to terminal n in the figure the potential difference between a and n, where n represents the reference terminal. Such a designation tends to imply that a and n have certain electrical potentials in space that can be specified in terms of physical position. This is perfectly true if the source of all electrification in the region is static electric charges. However, under present conditions, the source of power in all electric circuits of any industrial importance, in terms of the power handled, is some form of electromagnetic generator in which the electromotive force is produced by relative motion of conductors and magnetic fields or by changing magnetic flux linkages. If any path between the terminals lies in a region of varying magnetic field, the concept of a definite space potential is insufficient and inadequate.

The quantity measured by a voltmeter is understood to be the line integral of the electric intensity along the path between the two terminals, regardless of whether the electrical intensity is produced by electric charges in spaces, by varying magnetic fields, or by the two together in any combination. The result will simply be called the voltage between a and n.

To the practicing engineer who uses the term "voltage" daily, this may seem obvious, but among purists there is a feeling that the word is a corruption from "volt," the unit of the quantity measured, and that the use of the word should be suppressed. Some idea of this strange situation may be gained by trying to find an adequate definition of "voltage" in a text book or in the American Standard Definitions of Electrical Terms.[2] Nevertheless, the complete lack of any other term which clearly describes the quantity desired under general conditions makes the use of the term "voltage" not only desirable but essential.

If the magnetic field is varying in the region of the terminals a and n, it follows

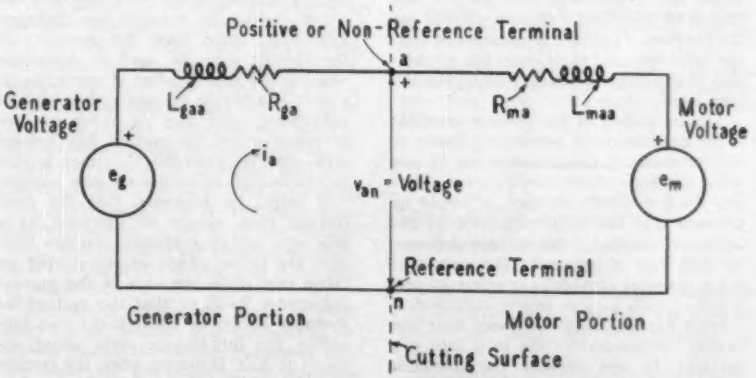

Fig. 1. Circuit conventions.

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that the voltage measured may depend upon the path selected for the voltmeter leads from a to n. Although this phenomenon must be considered on occasion, it is not particularly pertinent to the present discussion, and it will be assumed that the voltage will be the same by any suitable path lying in the surface which cuts the circuit.

The voltage from a to n is positive and is represented by a positive number if it would cause a flow of positive charges from a to n through a test resistor having a high resistance. A high resistance is suggested so that such a test current would not disturb the electric and magnetic fields appreciably. Conversely, if positive charges would flow from n to a, the voltage would be negative and would be represented by a negative number.

Voltage may be represented by the symbols e or v, with appropriate subscripts. Frequently two subscripts are used to denote the terminals between which the voltage is measured. In such cases, the order of the subscripts may indicate the reference polarity, that is, which terminal is the reference terminal and which the nonreference terminal. Practice in this regard is far from uniform, some designating the reference terminal by the second subscript, others by the first, and some using both practices, one when the voltage is measured across a load and the other when the voltage is an electromotive force or source. Simplicity suggests at least that only one practice be used, and it has been recommended that generally the reference terminal be denoted by the second subscript.[1] If this is done, a positive voltage will always produce a (positive) current from the terminal of the first subscript to the terminal of the second subscript, through an external test resistor. Where double subscripts have been used for currents, the reference direction of the current is universally from the first subscript to the second, and the recommended use of voltage subscripts is consistent with this, under the requirement that the test current is in an external resistor, utilized for the purpose. Thus, the assignment of voltage subscripts and their order has no relation to the direction of current within the loop itself.

The indication of the positive terminal is the designation of reference polarity at the terminals. If the circuit is cut by any other cutting surfaces which do not intersect the first within the loop, it would be assumed that the relative location of the reference terminal would be kept the same for each pair of terminals. However, that is not essential provided the reference terminal of each pair is clearly indicated.

From Fig. 1, it is clearly seen that the cutting surface divides the loop into two portions. In one portion, the reference current direction is toward the positive or nonreference terminal from the reference terminal, and in the other portion, the reverse is true. Reversing the reference direction of current without reversing the reference polarity simply interchanges the relationships. Thus, in any circuit which is cut by a surface, two conditions exist. It is convenient to be able to examine and analyze each portion separately. In Fig. 1, the left portion has the characteristics of a generator or source, the reference current direction being toward the positive terminal, as it would be directed toward an external load. The right portion has the characteristics of a load, current from a terminal voltage being directed toward a load, such as the motor indicated. In studying the individual devices or machines, it is convenient to deal with each portion separately, the detailed characteristics of the other not being an immediate consideration. Formulation of the basic laws in mathematical form should recognize the two basic situations and be adapted accordingly, or the situation for which the formulation is given should be stated, so that adaptation to the other can be readily made.

Flux Linkage

In Fig. 1, an inductive circuit is shown, with an inductance in each portion. The presence of current in an inductance causes magnetic flux which links the turns of the inductance to give rise to magnetic flux linkage. In formulating the law for the voltage produced by any change of flux linkage, it is desirable to have a reference direction or sign for flux linkages. In the interest of simplicity, and to minimize the number of arbitrary conventions, it is suggested that the flux linkages of a circuit or portion of a circuit produced by positive current in that portion of the circuit always automatically be designated as positive.

The importance of this designation becomes more apparent when it is realized that a circuit element may be linked not only by flux arising from its own current through the parameter of self-inductance, but also by flux produced by currents in one or more other adjacent circuits possessing the parameters of mutual inductance with the first circuit. The flux produced by positive currents in other circuits may add to or oppose the flux produced by positive current in the circuit being examined, so that mutual effects from positive currents may produce either positive or negative flux linkages. Knowledge based upon the geometry of the circuits must be used to determine whether the mutual effect of any adjacent circuit is additive or subtractive. Mutual inductance itself may be either positive or negative and the mutual flux linkage term may be preceded by either a plus or minus sign as conditions may require.

It might be suggested that the flux-linkage term always be preceded by a plus sign, and that whether the flux linkages are to be added or substracted be taken care of by the sign of the mutual inductance itself, or that the mutual inductance always be positive, the sign preceding the flux-linkage term being adjusted to suit. However, when the circuits are subjected to relative motion, the effect may reverse during the motion and any such limitations may become restrictive. Thus, the practical solution is to determine the mutual inductance from the geometry of the problem, assigning whichever sign is more appropriate. Then, after all reference current directions have been assigned, the sign of the mutual flux-linkage term is determined—a plus sign if flux linkages produced by current in the reference direction in the first circuit are increased by the flux linkages produced by current in the reference direction in the second circuit when this mutual inductance is positive or by current in the reverse direction when the mutual inductance is negative, and a minus sign otherwise.

However, if the recommendation of this section is followed, self-inductance may and should always be positive, and current in the reference direction will always produce positive flux linkages in its own circuit, so that this term in the formulation of the expression for flux linkages will always be positive. Failure to follow this basic rule increases the possibilities of error or confusion.

With the understanding that the loop shown in Fig. 1 may be coupled with adjacent loops, not shown, the flux linkages of each section may be written

$$\lambda_{ga} = L_{gaa}i_a \pm L_{gab}i_b \pm L_{gac}i_c \pm \dots$$
$$\lambda_{ma} = L_{maa}i_a \pm L_{mab}i_b \pm L_{mac}i_c \pm \dots \qquad (1)$$

Here the terms L_{gab}, L_{mab}, etc., represent the mutual inductances between the appropriate portion, g or m of the loop and the adjacent loops b, etc., and, as previously discussed, they may be positive, negative, or variable. However, for a particular condition, the value will be definite in each actual case, and from that condition and the geometry of the circuit the specific sign to be applied to the term can be established.

Electromagnetic Voltage Generation

The voltage produced by electromagnetic induction is most often expressed by the relation

$$e = -N\frac{d\phi}{dt} = -\frac{d\lambda}{dt} \qquad (2)$$

some authorities using $N\phi$ as the product of flux and turns instead of a symbol for flux linkage. Because, in most circuits, all of the flux does not link all of the turns, any actual formulation must involve the summation of partial fluxes multiplied by the turns linked. Thus, it seems best to introduce a symbol for flux linkages at the outset. Although there is no definite standard symbol for flux linkage, λ seems the most likely for ultimate standardization and will be used here, but other symbols have been extensively used in specific areas.

In the presentation of equation 2, it is not always indicated that conventions regarding sign of flux linkage and voltage polarity are implied, and if the conventions assumed are not those adopted, the sign should be reversed. Actually, equation 2 applies to the generator portion of the circuit, and should be written

$$v_{an(\text{Inductive})} = -\frac{d\lambda_{ga}}{dt} \qquad (3)$$

in which $v_{an(\text{Inductive})}$ denotes the portion of v_{an} which results from inductive action.

When applied to the motor or load portion of the circuit, the sign of the flux linkages has been reversed relative to the voltage polarity, and the corresponding equation should be written

$$v_{an\ \text{Inductive}} = \frac{d\lambda_{ma}}{dt} \qquad (4)$$

Of course, it does not follow that the voltages of equations 3 and 4 are equal. Each is a portion of the total voltage resulting from the electromagnetic induction only, and it is only the total voltage as determined from each side which must be the same, inasmuch as the two portions of the circuit are connected together.

The important point is that the formulation of the law of electromagnetic induction depends upon conventions regarding signs of flux linkage and voltage polarity, and the sign in the equation depends upon the choices. Because every loop is capable of division into generator and load or motor portions, both conditions may be expected, and should be provided for.

Complete Voltage Equations

In the solution of circuits involving closed loops, Kirchhoff's Laws are used to write the voltage equation for each closed loop. However, when the loop is divided, as in Fig. 1, it is desirable to write the voltage equation for each portion separately. It is worth pointing out that the relations for the two portions differ because of the different relative relations between current reference direction and voltage reference polarity.

Depending upon the method of representation used and the type of analysis being undertaken, each portion may be assumed to contain an electromotive force. For completeness, each electromotive force must have a reference polarity to indicate the positive terminal when the voltage of the source is numerically positive. In Fig. 1, both e_g and e_m are assumed to have the positive terminal at the top. Then, following Kirchhoff's Laws, the voltage v_{an} at the terminals a and n can be expressed in two ways, in terms of the generator portion and in terms of the motor portion. These are

$$v_{an} = e_g - \frac{d\lambda_{ga}}{dt} - R_{ga}i_a$$

$$v_{an} = e_m + \frac{d\lambda_{ma}}{dt} + R_{ma}i_a \qquad (5)$$

Of course, since the circuit is closed, these two values must be the same. However, attention may be directed to either portion, and detailed analysis of the other may often be omitted entirely, depending upon the problem.

As previously suggested, the electromotive forces of generators and motors are most often produced by electromagnetic action, as by the rotation of a magnetic field. Thus, if the circuits represented included the field circuits of the generator and motor, it would be appropriate to eliminate e_g and e_m, and include the effects by incorporating in λ_{ga} and λ_{ma} the magnetic interlinkages with the fields. The changing of the flux linkages as the fields revolved would produce the equivalent voltages that had been represented by e_g and e_m. Thus, there are alternatives in circuit analysis which depend upon the detail required and the purpose of the analysis. Obviously, also, there are innumerable variations in circuit arrangements that are possible, and only one possibility has been shown here, to illustrate the conventions needed.

The important point is that the voltage equations for the two portions differ in signs, yet each is appropriate for its portion.

Phasor Representation—Polyphase Circuits

There is one convention in circuit analysis which has been the subject of international standardization. It is that when a directed line in a plane is used to represent a sinusoidal alternating quantity, it shall be understood that the line rotates, that the projection of the line on a reference axis shall be proportional to the instantaneous value of the quantity represented, and the positive direction of rotation (for increasing time) shall be counterclockwise. Thus, positive angle is measured counterclockwise. Overemphasis on this one convention has tended to complicate situations that can be kept more simple.

At the present time, the directed lines are called phasors, and their length is normally selected to represent the rms value of the sinusoidal quantity. On a diagram, the line can of course be shown in one position only, corresponding to some selected instant of time. However, if the phasors representing related quantities are shown for the same instant of time, from the same origin, their relative angular positions will show the relative timing of the quantities in reaching their maximum values. The instantaneous value of the quantity, for the instant represented, is the projection of the phasor on the reference axis, multiplied by $\sqrt{2}$, because the rms value is the maximum value divided by $\sqrt{2}$.

There has been no universal agreement as to which axis should be chosen as the reference axis. For pictorial representation, to show that the sine-wave variation is represented as the phasor rotates, the vertical axis is often preferred. However, since the mathematical analysis of phasor relations regularly utilizes complex numbers, it is usually preferable to select the horizontal axis, the axis of reals, as the reference axis. It is awkward and confusing to find that the "real" quantity, that is, the magnitude of the quantity being represented, is given by the "imaginary" component of the complex number, as is the case if the vertical axis is the axis of reference.

Fortunately, this choice is not of great consequence, because it is the relative relations among the phasor quantities that are important, and changing the reference axis is equivalent to changing the instant of time portrayed by the diagram. In most cases, the time instant represented is not significant, because the relative relations in the steady state are not changing.

Basically, a polyphase system consists of a series of circuits, normally duplicate, so arranged that voltages of equal magnitude are generated in each, but the phase relations are such that the voltage in each succeeding phase lags the preceding one by the same fraction of a cycle in time. While many systems are possible, the 3-phase system predominates and is the only one that need be examined here. If the three phases are denoted by a, b, and c, it will be assumed that the three line-to-neutral voltages reach their maxima in that order. Then the phasor diagram of the three voltages V_{an}, V_{bn}, and V_{cn} at some instant of time is represented by Fig. 2.

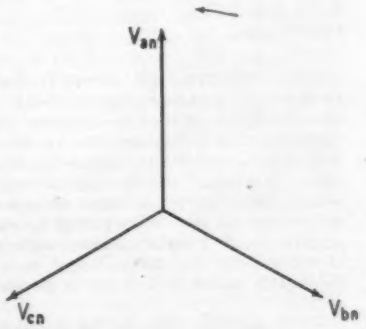

Fig. 2. Voltage phasors for a 3-phase system.

It is to be noted that succeeding phasors are arranged in *clockwise* order, so that, as they rotate in the *counterclockwise* or forward direction, they will have maximum projections on any selected reference axis in the order a, b, c.

References

1. Voltage Notation Conventions, M. B. Reed, W. A. Lewis. *Electrical Engineering*, vol. 67, no. 1, Jan. 1948, pp. 41-48.

2. Definition of Electrical Terms. *American Standard C-42*, American Standards Association, New York, N. Y., published by AIEE, 1941.

Electrical Engineering Education

Outstanding Engineer at University of Idaho

Lowell Vanskike was named "Outstanding Engineer of the Year" by the Student Branch of AIEE at the University of Idaho.

In addition to having a high scholastic record, he served as AIEE Branch chairman and was active in Sigma Tau.

Electrical Engineering Education

Trinity College Offers Five-Year Engineering Plan

A five-year engineering program beginning September 1958 has been announced by Trinity College President A. C. Jacobs.

Trinity grants bachelor degrees in both the arts and the sciences. The fifth year will permit specialization so that students, in addition to the bachelor of science degree, will earn one of three scientific degrees: bachelor of science in mechanical engineering, in electrical engineering, or in engineering science.

In connection with the plan, new equipment, including a torsion machine, steam turbine, new boiler, electrical equipment, and special heat transfer units, will be added to the Hallden Engineering Laboratory.

H. J. Lockwood, Hallden professor of engineering at Trinity, said that the engineering curriculum is so designed that the students will receive the same basic instruction during the first three years. Selecting a specific field, therefore, can come as late as the senior year.

The fifth year of the new Trinity program is not limited to B.S. graduates from Trinity.

Electrical Engineering Education for the Future

P. M. HONNELL
FELLOW AIEE

THE ULTIMATE DESTINY of Western Civilization, indeed its very survival, is now in direct ratio to the quality and quantity of its technology. This, in turn, is measurably related to engineering education in general, and to electrical engineering education in particular, by reason of the central role of electricity in the modern world. These are historic realities of the present day, acknowledged by all thoughtful leaders in and out of Government.

There are many facets to this situation: national defense-in-being, so much a part of our present life, relies very heavily upon modern technology. The complexity of ground, sea, and air armament, presently—or soon to be—in the hands of our defense forces, raises serious questions related not only to its needs, costs, procurement, and maintenance; but also questions related to its effective employment. This now more than ever depends upon the intellectual caliber and the level of education of the personnel in the Armed Forces.

A more far-reaching and perhaps, in the long run, a more decisive facet of this situation is the relation of engineering education to technological productivity. Sir Ewart Smith,[1] in an analysis of the critical importance of technological education in relation to productivity, which he defines as the ratio of volume output of the national product to the numbers of persons at all levels employed in that process, shows that the United States has gained steadily in productivity over the past half-century, and now is 2½ to 3 times more productive than Great Britain. Sir Ewart's analysis indicates that although Britain continues to maintain a high level of leadership in the pure sciences, the relatively low productivity of Great Britain is in great measure the result of the shortage of people trained in the application of science to industrial needs; to the lack of engineers, in other words. The need of the United Kingdom for more scientists and technologists during the new technological revolution has been clearly stated, and the urgency of the situation explained, in a White Paper on Technical Education issued in February 1956. The net result: the expansion of engineering education facilities in the United Kingdom now in progress.

Our own Dr. Gustav Mesmer, director of the Graduate Engineering Division of Washington University, is on leave this year at the Technische Hochschule in Darmstadt, West Germany, assisting in the establishment of an expanded program of undergraduate engineering education, akin in some respects to that which exists here in the United States.

In France, the expansion of scientific educational facilities is also under way; a report in *Product Engineering*[2] indicates the difficulties encountered in the location of new science buildings at the University of Paris, which expects to double its present science course enrollment within 10 years.

Here in the United States, we have had the White House Conference on Education, and President Eisenhower's Committee on Education Beyond the High School, which have considered and recommended specific steps to improve education, and to increase educational facilities.

The Immediate Urgency of the Situation

The increasing importance of technology, and the need for larger numbers of engineers in the economy are not the sole bases for the increased educational activity throughout the Western World. The more compelling factors are population growths, and the USSR.

In the United States, the known increase in population will result in doubling the present educational enrollment within the next 10 to 15 years. This gives very little spare time prior to taking the necessary actions at all educational levels to meet these staggering requirements.

The principal motivation is, however, the realization throughout the West of the established emergence of the USSR—within a period of 40 years and in spite of a devastating war—as a dominant world power, not only militarily but technologically as well; a power which is definitely antagonistic toward the West. The antagonism was clearly described by Sir Winston Churchill in his famous speech at Westminister College in Fulton, Mo., an event which crystallized public opinion.

The synchronous technological advances of the Soviets were not so clearly understood and, more to the point, not believed by the general public until the dramatic events of the Sputnik launchings. This situation was somewhat promoted by official governmental policy, perhaps rightly, which hampered dissemination of Soviet publications for fear of propaganda value. On the other hand, discerning scientists throughout the world were aware of the true state of affairs. Furthermore, as E. J. Tangerman[3] points out, the USSR made available the scientific and technical literature, and, thereby, the full extent of the scientific and technological advances in the West, to its own scientists and engineers. In other words, the United States was short-circuiting some very useful sources of available technical information.

The immediate urgency of the situation, therefore, stems both from an increase of population, particularly in the United States, and the emergence of an antagonistic world power ruthlessly wielding both military and technological might which may attempt world-wide domination.

The Long-Term Situation

It must not be forgotten that the role which the USSR is now attempting to play was formerly enacted by the West, principally the European nations. For almost a half-millenium Europe dominated the known world and, thus, the West had complete access to all the world treasures. But the historical times have changed, a process no doubt accelerated by two suicidal World Wars. In this period, the United States emerged from the position of a young nation with immense natural resources, high ideals, and a limited importance in the affairs of the world powers, to the dominant power of the West. But this latter event has not been achieved without some real extravagances. The resources of the United States have almost been exhausted in 50 years, a process which took Western Europe two millenia to accomplish. Since the period 1940-50, raw material requirements of the United States have exceeded its internal productive capabilities, and, thus, the United

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States has joined the company of the have-not nations.[4]

At the same time, the great bulk of the populations of the world are now emerging from a period of quiescence, the first act of which was the overthrow of the domination of the Colonial Powers, or of existing governments, a process still evident on all sides. The reference here is to China with a population of 6.4×10^8 people; to South and Southeast Asia with 6.3×10^8 people; and to Africa. The agitation of these peoples is evident in all segments of human activities.

It is, of course, easy to deprecate the abilities and potentialities of these peoples, although our very recent war history should disabuse us of any such notions. Consider as an example a single ingredient of a nation's culture: language. Language, especially written, everyone agrees is a necessary and important feature of communication within and between nations; if overly complicated, inflexible, or otherwise out-dated, it can be a bar to progress. Compare, therefore, the following items appearing recently in the *St. Louis Post-Dispatch:*

> Item (1) "Seoul, 30 December 1957 (AP)—President Syngman Rhee, a staunch anti-Communist, had a good word for Red China yesterday.
>
> In a statement Rhee praised the recent Red Chinese decision to adopt the Latin alphabet and junk the ancient ideographs or characters of multiple strokes.
>
> 'Even those opposed to the Communists can offer nothing but tributes for such a forward looking step' Rhee said."

> Item (2.1) "London, 20 February 1958 (AP)—A British judge today threw out George Bernard Shaw's plan to bequeath his fortune to simplify the English alphabet.
>
> High Court Justice Sir Charles Harman ruled that the Irish playwright's project would involve a change in the law of the land, and was therefore impractical and invalid. . . .
>
> The estate is now worth $2,004,800. and is growing all the time."

> Item (2.2) "London, 28 February 1958 (UP)—British authorities offered a $1,400 prize today for the best 40-letter English alphabet in which 'every sound in our speech can be written with one graphic and easily written symbol.'
>
> Public Trustee R. O. Baulkwill announced the contest on behalf of the late George Bernard Shaw, who provided funds for it in his will."

Surely these dispatches speak emphatically: of renewed energy and vitality on one side; of complacency, or lethargy, on the other.

If it were only a matter of language, perhaps the West could remain complacent. But that is only a symbol of the activity. Similar enterprise is also being shown in education.[5]

In another editorial, *Product Engineering*[6] quotes a report from Hong Kong which states that ". . . China has begun to export diesel engines to Egypt and Syria. She is also exporting rubber tires to Finland, Burma, Ceylon, and Syria; textile knitting and other machines, as well as soap machinery, to Indonesia, Egypt, and Burma."

It is clear, therefore, that as soon as these large masses of the world's population bring themselves up to an industrial potential even remotely comparable to that of the West, they will divert raw material, much of which they control, to their own manufactures, thereby depriving the West of these needed resources. This time is not far off.

What does this have to do with education? It has everything to do with education, with higher education. The only permanent way in which deficiencies in material supplies can be counterbalanced and the defenses and standard of living of the West be maintained is by a wiser utilization of natural resources, no matter where acquired. These resources must be more intelligently procured and husbanded; and the designs and manufactures must be improved in the engineering as well as in the sales appeal sense. These objectives can be achieved only through technological skills and advances. In other words, the "intelligence content" of the technology of the West must be drastically increased. This is possible only with higher scientific and engineering education as its foundation.

For all these reasons, therefore, population growth, economic conflict, defense needs, the West is marshalling its forces for survival, a process in which education will play an increasingly important role.

Present Status of Engineering Education

Is engineering education, and particularly electrical engineering education rising to the new demands of the situation? Although difficult to answer categorically, the answer in the main must be an emphatic "No, not yet." This is perhaps to be expected in so vast, so complex, an undertaking. As the author in the section on education in the *Encyclopaedia Britannica*[7] clearly states: "Schools and universities are naturally conservative and bound by tradition. They are slow to leave the old paths which have hitherto led to the desired goal, and to enter on new and untried ways."

What then are the present deficiencies in electrical engineering education? They are many, as is well known. To name but a few: inadequate physical plant; inadequate financial support; inadequate teaching facilities; inadequate preparation of entering students; inadequate curriculum scope, breadth, and objectives; and, perhaps most important of all, inadequate academic staffs.

Lest this view be termed too pessimistic, let it be clearly understood that electrical engineering education of today is in some ways superior to that of the immediate past, as a glance at the new American engineering textbooks will indicate. In fact, engineering education of today is undoubtedly an excellent preparation for the decades starting in 1930! But is it an adequate preparation of our young people for the future roles they will be called upon to assume?

Consider some published comments on

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engineering education: Professor Walter LaPierre in *Electrical Engineering*[8] writes "It is possible to view the break of the dawn of the atomic age with equanimity, *if one is dead;* but under no other circumstances. The same may be said of engineering education." Professor Naim Abou-Taleb in the *Journal of Engineering Education*[9] implies diplomatically that all is not well in American engineering schools. Professor D. L. Trautman in the same *Journal*[10] makes some rather emphatic observations "1. It appears that the nature of engineering education is almost everywhere the same—training for routine doing. 2. Potentialities of the student as a learner or as a creative individual in general are not exploited. 3. The vigorous evolution of engineering education is hampered by: (A) complacent, inbred, and conservative teachers; (B) dissonant administrative framework; and (C) a blurred view of the essence of engineering education." Provost F. E. Terman speaking at an AIEE[11] meeting said "In the last decade, important changes have taken place in the education of electrical engineers. These, in part, have come in response to new needs. A factor, however, has been an underlying dissatisfaction with the inadequacies of the typical training of the prewar electrical engineer."

The dissatisfaction with the existing status of electrical engineering education is reflected in physics education. Consider the statement[12] of the chairman of the department of physics at Massachusetts Institute of Technology, Prof. N. H. Frank ". . . I will drop all semblance of tact and state categorically that in my judgment the average elementary college physics course falls far short of even modest intellectual standards and fails utterly to satisfy present-day requirements in physics education. This situation is deplorable, to say the least. I am amazed, not so much that high school physics leaves so much to be desired, but that it is as good as it is, when one considers the low quality of beginning college physics courses . . ." These are strongly worded views; that they are representative of the physics situation is acknowledged by the activities of the American Association of Physics Teachers[13, 14] on improving the quality and effectiveness of introductory physics courses.

If the situation is deplorable in physics, there are few adjectives remaining to define the situation in electrical engineering. For as bad as the physics situation is, it is incomparably superior to that in electrical engineering. Consider these factors: the physicists now teach, and utilize, and exploit almost all the techniques and apparatus of the electrical engineer: power, servo, electronics, microwave, solid-state devices; they have higher and lower frequency devices; higher and lower powered devices; the most complex and the most

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fundamental. What does this leave the electrical engineer? The dubious role of service-technician! If this is an over-exaggeration, look around any campus. Which buildings are lit up far into the night? engineering, or physics? To which curriculum do the best students gravitate, engineering? Or engineering science or physics (no matter what it is called) and, thus, ultimately into physics proper?

What is the attitude of Government, business, and industry toward this situation? The Federal Government is probably more fully aware of the status of, and has done more to promote, higher engineering education than is generally recognized; but our Government necessarily reflects the views of the majority, so that it has not yet grappled with the real problem on a sufficiently grand scale. Business and industry generally, with some notable exceptions, are primarily concerned with the crisis in engineering education only as it may represent a short-term shortage of personnel. One of the exceptions is the sustained, informed, and dynamic presentation of the crisis in education which has appeared in the pages of McGraw-Hill Publishing Company journals[15, 16] under the guidance of D. C. McGraw; other exceptions are scholarships supported by the General Electric Company, Westinghouse Electric Corporation, Procter and Gamble, and many others. But this is not a sufficiently broad base of support.

It has long been recognized that depletion of our natural resources has often taken place at a rate which completely disregards the needs of the future. It has not as commonly been recognized that our intellectual resources have also been depleted. A machine tool becomes obsolescent in 10 to 20 years; and in electronics even more quickly. But rapid obsolescence is also true of the present type of training of engineering students. Employers have been satisfied to get a product which has been selected, and trained, by engineering colleges to an extent that the student is immediately useful, a process stimulated by the apparent shortage of the product. The young engineering graduate under the economic pressures of the day enters business or industry without realizing that he is part of a rather vicious cycle. For, with his 4 years of training, he is almost totally unprepared for the exigencies of the future. He finds—too late—that his training is inadequate and his real potential, except in very unusual cases, is never attained. Furthermore, the older engineer discovers some 10 to 15 years later that a new crop of young engineers with a necessarily better training for the moment, rapidly by-pass him. Although this may be a permissible procedure in a fluid economy of plenty, it is not equitable to the student, nor to his parents who paid for his college days, nor to the nation. This is, in fact, a ruthless depletion of one of our most critical resources, those of the intellect.

A final blow: In a summary of its findings of a Management Audit[17] of the Procter and Gamble Company, the American Institute of Management includes as one of 13 suggestions for improvement of an excellently managed company the following "7. More scientists might be brought from Europe for technical research activities." Note that this does not suggest the employment of more American educated scientists and engineers. Is this to be construed as the judgment of American management on the potentialities of our American-educated scientists and engineers? In all fairness, the following suggestion must also be included "11. A nation-wide program of having executives aid colleges in their business courses and training programs should be established." But clearly, this does not apply to science nor engineering.

Crisis and Decision

Since World War II, engineering education has been exhausted by many heavy burdens caused by readjustment from an all-out war to a quasi-peace; exhausted with an unprecedented peak of students returning from war services; exhausted by stop-gap efforts to increase the number of engineers with more than bachelor's attainments for service in industry and Government, to meet threats symbolized by the Iron Curtain.

But engineering education is at the cross-roads; the time of crisis is now. Either engineering education positively promotes the progress of engineering toward the goal of becoming a truly great profession, or it does not.

The decision to be faced is: Are Engineers to be truly educated, prepared to meet the enormous tasks ahead? Or are engineers to continue to be in a twilight zone, neither educated in a discipline with stature, nor quite merely trained for vocational occupations?

Educational crises are not new. At the turn of the century, medical education in this country was a disgrace; but the force of public opinion and the efforts of leaders in the profession remolded the entire system and today American medicine is unequalled in the entire world. We are now witnessing the awakening of the American public to the inadequacies and deficiencies in elementary and high schools, deplorable conditions often in the midst of beautiful buildings and surroundings.

Once the facts are known and the situation explained, the unequivocal decision will be: Students choosing engineering must be truly educated.

The Solutions

Execution of the mandate and achieving the goals will require funds, faculty, and —most important of all—inspired, dedicated, academic leadership.

Shunting aside the enormous problems of financing[18] private and public universities and realistic estimates of the costs involved; shunting aside the relative merits of improved facilities and faculties versus scholarship programs;[19] and mentioning, only in passing, that England has a scheme for financing both types of institutions; consider only academic objectives and leadership. Does America enjoy institutions truly providing education for an engineering profession?

The answer is an emphatic *yes*. Sir Ewart[20] lists as the great technological institutes: Zurich, Stockholm, Charlottenburg, Delft, Massachusetts Institute of Technology, California Institute of Technology, and politely "etc." What then are the uncommon characteristics of the only two American institutions recognized in this listing?

First of all, these institutions demand scholarly attainments from students and faculty alike; second, these institutions have outstanding graduate divisions as well as undergraduate divisions; third, they have a balance between strong, independent, scholarly departments in science, in the humanities, and in engineering; fourth, the curricula maintain a balance between the humanities, the sciences, and the technologies; fifth, research is an integral part of the educational process for both undergraduate and graduate students. Furthermore, the academic leaders of these outstanding American institutions have spoken out time after time on objectives, on principles, and on the methods followed in achieving their enviable status. The information is not classified; it is available to everyone! In the annual *Bulletins*,[21, 22] in the annual Presidential reports,[23, 24] and in innumerable addresses and committee reports. For example, on the relation of fundamental research to teaching, Dr. J. R. Killian, Jr., writes:[25] "Teaching of the highest type, especially in science and its applications, thrives best in the stimulating atmosphere of creative work at the boundaries of human knowledge. He who is still a student, who is still himself learning, can best guide those about to enter on professional careers." In an address on Science and the Educated Man, Chancellor J. A. Stratton[26] said: "Engineering education will attain professional stature by a concern for principles, a ceaseless reaching down for fundamentals, and a rejection of the immediately useful in favor of a painstaking search for understanding."

Consider some applications of these broad principles to engineering education. First of all, they demand that students who cannot, or do not, or will not display scholastic proficiency must be limited to curtailed curricula, perhaps less than a 4-year span; conversely, an honors program biased toward the master's and doctor's level must be available at all levels for those students demonstrating academic scholarship and professional leadership. There can be no place for secondary-school attitudes, nor for vocationalism, nor for fractionally distillated series of topics in a curriculum; rather, there must be a broad, balanced program of studies forming an integrated, unified core of subjects at the same high level for all engineering students, without regard to the ultimate branches of engineering, in the undergraduate divisions. All subjects must be presented in depth; for example, the objective of the sequence in English is not merely to develop an ability for writing acceptable "engineering reports" but fur-

ther to cultivate an appreciation for the wisdom of the world expressed in the English language. Similarly, the study of a foreign language is not merely a preparation for successful accomplishment of a reading test for the doctorate, but rather to the end that the culture, history, and philosophies of the country of origin of the language be appreciated. Clearly, a sequence in mathematics to an extent not envisioned in the past is required; economics or more accurately econometrics is essential to the engineer; so are physics, chemistry, and those scientific portions of engineering which are of fundamental importance and lasting value. A return must be made to the foundations of all physical sciences, the laboratory, intelligently utilized and coequal with theoretical instruction. All students in the honors program must, in their earlier years, assist in research programs; and at the graduate level proceed to significant research efforts of their own. Finally, faculty and students alike must display an appreciation of and love for knowledge as exemplified by research in its broadest sense.

Conclusion

To sum up, electrical engineering education for the future cannot be described in terms of a syllabus for a curriculum. It cannot be achieved by playing the great indoor sport of the educational world, "tinkering with the curriculum," in the words of Dean Emeritus Langsdorf.[27]

It is only in the true liberal tradition, albeit in a modern version, that education in electrical engineering can prepare young students for leadership in the complex of the future. The true liberal tradition in which: "L'éducation proprement dite est *générale* par définition et *libéral*, puisqu'elle doit former l'homme tout entier, et l'homme libre."[28] Briefly, "Education is general by definition, and liberal, since it should mold the entire man, and the free man." As Dr DuBridge has aptly stated,[29] ". . . the word liberal can hardly be disassociated from the concept of liberation—the act of freeing. Liberal education, then, frees men's minds, frees them from the chains of ignorance, superstition, and fear, frees them from the atrophy which comes from lack of being used. A man with a free mind is simply a man prepared to act intelligently." It might be added that a free mind is prepared to attack new problems with assurance, without hesitation, and without prejudices.

Thus, and only thus, may the electrical engineer truly be educated, prepared for the arduous tasks of leadership, and the responsibilities of command.

> "I must admit that I have a highly prejudiced, almost emotional, feeling about universities. I happen to think that they are about the most important institutions in the Western World. I believe they have made contributions to western civilization—physical, intellectual, and spiritual contributions—which are beyond the powers of any man to compute or comprehend. And I believe that the nature of the civilization that our grandchildren will inherit on this earth will depend in a critical, possibly in a decisive, degree on what our universities do, or fail to do, in coming years."
>
> Dr. L. A. DuBridge[30]

References

1. The Critical Importance of Higher Technological Education in Relation to Productivity, Sir Ewart Smith. *American Scientist*, New Haven, Conn., vol. 39, no. 2, April 1951, pp. 274-86.

2. Struggle for Science Simmers on Seine. *Product Engineering*, New York, N.Y., Feb. 24, 1958, p. 23.

3. Why We Need to Know, E. J. Tangerman. *Product Engineering*, New York, N.Y., Dec. 16, 1957, pp. 24-29.

4. National Resources Conference, Presentation Outlines, *Industrial College of the Armed Forces*, Washington, D.C., 1957-58, p. 79.

5. The Development of Education in Mainland China, R. F. Simpson. Special Issue, Problems and Promises of Education in Asia. *Phi Delta Kappan*, Bloomington, Ind., vol. XXXIX, no. 3, Dec. 1957.

6. Editorial, *Product Engineering*, New York, N.Y., March 3, 1958.

7. *Encyclopedia Britannica*, London, England, 13th Edition, 1926, p. 951.

8. An Immoderate View of Undergraduate Engineering Education, Walter LaPierre. *Electrical Engineering*, April 1951, pp. 299-303.

9. A Foreign Professor's Evaluation of Engineering Education, Naim Abou-Taleb. *Journal of Engineering Education*, Lancaster, Pa., vol. 48, no. 5, Feb. 1958, pp. 387-89.

10. Engineering Education Across the Country, D. L. Trautman. *Journal of Engineering Education*, Lancaster, Pa., Nov. 1954, pp. 274-79.

11. Electrical Engineering Curricula in a Changing World. F. E. Terman. *Electrical Engineering*, Oct. 1956, pp. 940-41.

12. Critique of Teaching Objectives in Colleges, N. H. Frank. *Physics Today*, American Institute of Physics, New York, N.Y., vol 8, no. 6, June 1955, pp. 19-20.

13. Preliminary Report on the AAPT Conference on Improving the Quality and Effectiveness of Introductory Physics Courses. American Association of Physics Teachers, Carleton College, Northfield, Minn., September 5-8, 1956.

14. The Role of Physics in Engineering Education, Report, American Institute of Physics, *Physics Today*, vol. 8. no. 12, Dec. 1955, pp. 12-21.

Electrical Engineering Education

15. Our Colleges and Universities Are Living on Borrowed Time. *Electronics*, New York, N.Y., April 1955, pp. 59-60.

16. Business Help for Our Colleges a Job for *All* Business Firms. *Electronics*, New York, N.Y., June 1955, pp. 69-70.

17. Management Audit, The Procter and Gamble Company. *Special Audit*, The American Institute of Management no. 148, vol. VI, no. 14, Feb. 1957.

18. Improvement of the Engineer—Are We Willing To Pay for It? C. C. Furnas. *Journal of Engineering Education*, Lancaster, Pa., vol. 47, no. 9, May 1957, pp. 718-24.

19. Scholarships Not the Answer, R. F. Goheen. *St. Louis Post-Dispatch*, St. Louis, Mo., March 5, 1958, p. 3B.

20. The Critical Importance of Higher Technological Education in Relation to Productivity, Sir Ewart Smith. *American Scientist*, New Haven, Conn., vol. 39, no. 2, April 1951, p. 285.

21. *Bulletin*, Massachusetts Institute of Technology, General Catalog Issue 1958.

22. *Bulletin* of the California Institute of Technology, Catalog 1957-58 .

23. *Report of the President*, Massachusetts Institute of Technology, 1957.

24. *Annual Report 1956-57*. California Institute of Technology.

25. *Bulletin*, Massachusetts Institute of Technology, Catalog Issue, vol. 92, no. 6, July 1957, p. 2.

26. Science and the Educated Man, J. A. Stratton. *Physics Today*, April 1956, pp. 17-20.

27. Realism in Engineering Education, A. S. Langsdorf. *Electrical Engineering*, June 1946, pp. 251-54.

28. *La Grande Encyclopédie*, Tome 15, Paris, France (1890?), p. 583.

29. Science and Liberal Education, L. A. DuBridge. *The Bent of Tau Beta Pi*, University of Tennessee, Knoxville, Tenn., July 1951, pp. 95-98.

30. The Goals of University Research, L. A. DuBridge. *Electrical Engineering*, Sept. 1954.

AEC Exhibit "This Atomic World"

The U.S. Atomic Energy Commission's (AEC) oldest and most widely traveled high school demonstration-lecture exhibit, "This Atomic World," closed the 1957-58 school year with another imposing list of statistics to its credit.

At the start of the summer vacation, six units of "This Atomic World" had this year visited some 850 high schools in 36 states and the District of Columbia, and had brought its "Atoms-for-Peace" message to 760,000 persons—most of them students in secondary schools. This brings the grand total of schools visited since the program started in 1955 to 1,546 with a total audience of more than 1,275,000 in all 48 states.

"This Atomic World," like all the AEC's traveling exhibits, is managed for the AEC by the Museum Division of the Oak Ridge Institute of Nuclear Studies (ORINS)—a nonprofit educational corporation of 36 southern universities and colleges. The division also operates the American Museum of Atomic Energy, in Oak Ridge, Tenn., for the AEC.

The "This Atomic World" units are among the busiest of all the traveling exhibits, because the demonstration-lectures are given each day at a different school, and the exhibits managers who accompany the units usually give at least two demonstrations a day at each school. On an average day, the manager gives one or more assembly programs, from one to two hours in length, depending upon the size and nature of the student body. Later on in the day, he may give another session for science-club or science-faculty members. He usually also has a conference with the school librarian, to discuss books on nuclear energy that would be of value to the student body.

In a typical assembly presentation, the

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ORINS representative uses exhibits and demonstration equipment to explain in simple language the fundamentals of atomic energy and its comparisons with other types of energy. Illustrative charts, panels, and models are used to show how nuclear energy is released through radiation and fission, and to describe its many uses in agriculture, medicine, industry, and other fields. A particularly striking demonstration involves a small Van de Graaff electrostatic generator capable of producing 250,000 volts of static electricity; it is used to explain how larger models are used in physics laboratories to study atomic structure.

The program was started in 1955, on an experimental basis, with one unit. By 1957, seven units were in operation—six on regularly scheduled showings throughout the country, and one which was shown in the East Tennessee area as training for the Museum Division's exhibits managers. All AEC traveling exhibits are made available to qualified sponsors without charge.

A Method of Designing Transistor Switching Circuits

J. D. BURROUGHS
ASSOCIATE MEMBER AIEE

THE DESIGN of most transistor circuitry is done by means of a-c small signal parameters and a-c equivalent circuits. This procedure is quite similar to that used for vacuum tube circuit design where the familiar parameters μ, g_m, and r_p are used. However, when one wishes to design a circuit in which operation occurs over a greater range than that for which the a-c equivalent circuit applies, some other means of representing the transistor must be found. This article describes a method which uses equivalent circuits to represent the transistor in switching applications, where the transistor is either cut-off or driven to saturation. As with most equivalent circuit representations, this method allows a better visualization of the transistor operation and, as a result, circuit simplifications may be made which might otherwise be overlooked.

Discussion

The junction transistor in the common emitter configuration behaves quite similarly to a vacuum tube in the common cathode configuration. With the vacuum tube, the impedance between the plate and cathode may be controlled by a voltage applied to a control grid; in the junction transistor, the impedance between the collector and emitter may be controlled by the current flowing through the base-emitter junction.

The base-emitter junction has a volt-ampere characteristic which is quite similar to that of other p-n junctions such as are used as rectifiers. A typical base-emitter characteristic is shown in Fig. 1.

As collector current is made to flow through a transistor, the base-emitter characteristic shown in Fig. 1 will shift to the right by an amount dependent upon the average value of collector current. The shift, i.e., the increase in base-emitter voltage, is caused by an increase of minority carrier density at the base-emitter junction. This shifting effect is shown in Fig. 2. Normal a-c small-signal operation occurs in the lower curved region of these characteristics. At the positions marked *S* on each characteristic, saturation occurs. Therefore, it is in the region above the positions marked *S* that the transistor operates when saturated.

In the reverse direction, as shown in Fig. 1, the impedance of the base-emitter junction is quite high having a value in the order of a megohm or more. This high value of impedance will be encountered as long as the reverse voltage is kept below the value at which breakdown occurs. This value will vary for different transistors but, in general, will be about 10 or 15 volts. When the base-emitter junction is biased in the reverse direction, the transistor is cut off. Therefore, the effect of shifting caused by collector current in the forward direction is not present in the reverse direction.

From the preceding discussion, it becomes apparent that the forward base-emitter characteristic for a particular value of collector current may be represented by a single line as shown in Fig. 3. The slope of this line will be R_f, the value of forward resistance, and the x axis intercept will be some value, V_f. This characteristic may be represented by a battery V_f in

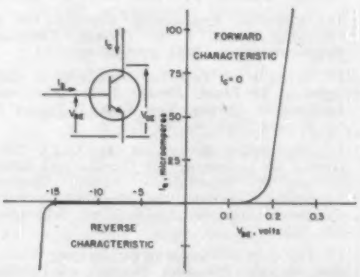


Fig. 1. Typical base-emitter junction volt-ampere characteristic.

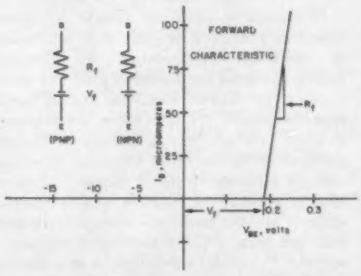
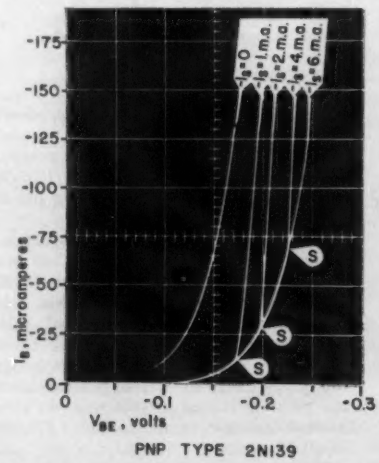


Fig. 3. Straight line representation of forward base-emitter junction characteristic and equivalent circuits.



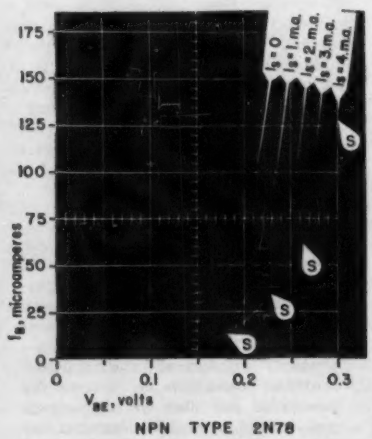


Fig. 2. Forward characteristics of base-emitter junctions showing the shifting effect caused by different values of saturated collector current, I_c.

Text of the paper that was awarded the National Branch Paper Prize at the general session of the AIEE Winter General Meeting held in New York, N. Y., Feb. 3, 1958.

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series with a resistance R_f as shown in Fig. 3.

In the reverse direction, the base-emitter junction can be represented by an open circuit as long as the applied voltage is kept below the value required for breakdown and other impedances in the circuit are low compared to the value of reverse impedance (in the order of one megohm).

Thus, we have equivalent circuits which represent the base-emitter junction of a transistor in each of the two states of a switching operation; i.e., saturation, and cutoff.

The collector–emitter behavior may best be seen from a typical junction transistor collector characteristic as shown in Fig. 4.

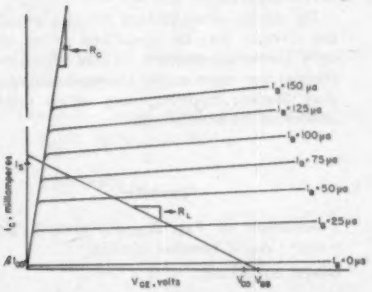

Fig. 4. Typical junction transistor collector characteristic. Grounded emitter configuration.

In the cutoff state, the collector–emitter impedance will be quite high, having a value given by:

$$R_{co} = \frac{V_{co}}{\beta I_{co}}. \qquad (1)$$

The collector-emitter impedance R_{co} will be in the order of 1 to 0.5 megohm and may, therefore, be considered as an open circuit if this value is high compared to other values of resistance in the circuit. In the saturated region, the collector–emitter impedance will be some small value R_C in the order of 50 ohms. This value of resistance may be obtained from the collector characteristics, as shown in Fig. 4.

Thus, we have equivalent circuit elements to represent both the base-emitter and the collector–emitter characteristics in both the cutoff and the saturated states. When put together, these elements make up two equivalent circuits, one for the cutoff state and another for the saturated state. These circuits are shown in Figs. 5 and 6.

As with all equivalent circuits, these circuits have limitations, and certain conditions must be met if they are to represent a transistor.

For the OFF or cutoff equivalent circuit to apply, the following conditions must be present:

1. The base-emitter voltage V_{be} must be of the polarity shown (for a p-n-p type transistor), and must have a value between zero and that required for breakdown.
2. The impedance of the other circuit parameters must be low compared to the

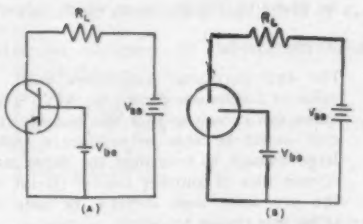

Fig. 5. (a) Junction transistor biased to cutoff. (b) Equivalent circuit for junction transistor biased to cutoff.

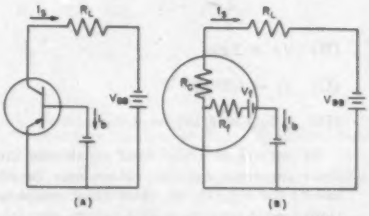

Fig. 6. (a) Junction transistor biased to saturation. (b) Equivalent circuit for junction transistor biased to saturation.

collector–emitter and base–emitter impedances.

For the ON or saturated equivalent circuit to apply the following conditions must be present:

1. The collector current I_s must be specified and the value of V_f determined which corresponds to this value of collector current. A method for determining V_f will be described later.
2. A value of base current, I_b, must be chosen which will cause saturation to occur for the specified value of collector current, I_s. This value of base current must satisfy the inequality:

$$I_b \geq \frac{I_s}{\beta} \qquad (2)$$

These conditions may be thought of as being similar to the limitations placed on a-c equivalent circuits when a particular operating point and load line are specified.

Application

The application of the circuits proposed to the design of a bistable or regenerative switching circuit will now be described. The desired circuit is one in which both transistors would be cut off in one stable state, and both would be on or saturated in the other stable state. This would differ from the usual Eccles–Jordan type of bistable circuit in which one transistor is on at all times. Such a circuit is shown in Fig. 7.

The problem is to determine values for V_{BB}, R_o, R_1, and R_L which will cause the circuit to be bistable. If the cutoff equivalent circuit is applied to the transistors in Fig. 7, the circuit will simplify to that shown in Fig. 8.

Applying the ON or saturated equivalent circuit, the circuit of Fig. 7 simplifies to that shown in Fig. 9.

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In order to solve for the four variable quantities V_{BB}, R_o, R_1, and R_L, four constraints must be established. One constraint may be taken from the first restricting condition which was placed upon the OFF equivalent circuit. This restriction limited V_{BB} to a value less than that required for breakdown. This value V_{be} may be written from the OFF equivalent circuit as:

$$V_{be} = \frac{V_{BB}\, R_o}{2R_o + R_1} \qquad (3)$$

For the circuit being designed, a value of 3 volts was chosen for V_{be}, because this value was well below that required for breakdown and would allow the circuit to be unaffected by noise pulses up to this value. A second constraint may be obtained by establishing the desired value of collector current in the ON condition. For the particular transistors used, this value was chosen as two milliamperes. In choosing I_s, the value of V_f to be used in

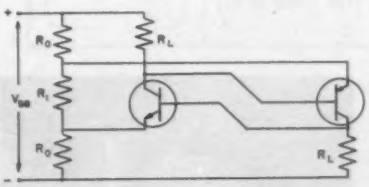

Fig. 7. Bistable circuit p-n-p/n-p-n

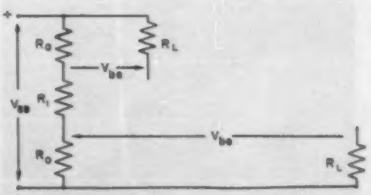

Fig. 8. Equivalent circuit representation of cutoff state.

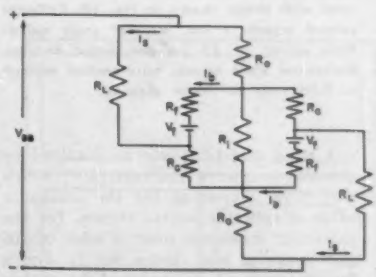

Fig. 9. Equivalent circuit representation of the ON or saturated state.

the ON equivalent circuit is also established, and must be determined by measurements on the transistors being used. One method of measuring this quantity is by means of the circuit shown in Fig. 10. Oscillographs obtained in this manner

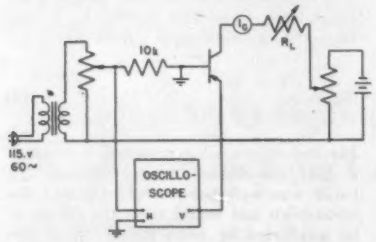

Fig. 10. Circuit used to obtain oscillographs of base-emitter characteristics.

are shown in Figs. 2 and 11. The straight portion of this curve is extended to determine the x axis intercept which gives the value of V_f.

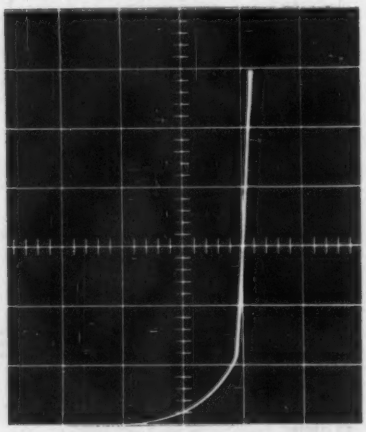

Fig. 11. Base-emitter characteristic as measured with circuit shown in Fig. 10. Collector current equals 2 ma. Vertical scale equals base curent = 25 μa per major division. Horizontal scale equals base-emitter voltage = 0.05 volts per major division.

A third constraint may be obtained by choosing a value of base current, I_b, which will cause saturation for the particular value of collector current chosen. For the particular transistors used, a value of 100 microamperes was chosen for I_b. For a fourth constraint, the value of the change in collector, ΔV_{CE}, between the ON and the OFF states was chosen. This voltage would be given by the equation which follows:

$$\Delta V_{CE} = I_S R_L \qquad (4)$$

For the particular transistors used, a value of 5 volts was chosen for ΔV_{CE}. This value was chosen so that one bistable circuit would be able to produce a pulse large enough to overcome the three volt reverse bias of another similar circuit in the OFF state, and, thereby, be able to cause this circuit to switch.

These four constraints may be stated for this particular application as:

$$\text{(A)} \quad V_{bc} = \frac{V_{BB}\, R_0}{2\, R_0 + R_1} = 3 \text{ volts}$$

$$\text{(B)} \quad I_S = 2 \text{ ma}$$

$$\text{(C)} \quad I_b = 100\ \mu a$$

$$\text{(D)} \quad \Delta V_{CE} = I_c\, R_L = 5 \text{ volts}$$

By means of these four equations and the equivalent circuits, values may be obtained for V_{BB}, R_0, R_1. (For these computations, see Appendix.) The values obtained are shown in Table I.

Table I

	Standard Values Actually Used
$V_{BB} = 9.875$ volts	10 volts
$R_0 = 2.05$ k Ω	2. k Ω
$R_1 = 2.65$ k Ω	2.7 k Ω
$R_L = 2.5$ k Ω	2.7 k Ω

The circuit was connected using the standard values of resistance shown in the table and was found to be quite stable in both the ON and the OFF state. Repetitive operation was obtained by connecting one of the bases to a source of alternative positive and negative pulses. In order to decrease the magnitude of the pulses required to switch the circuit, the emitters were connected to ground with 0.05 μf capacitors. The circuit and the resulting waveforms are shown in Figs. 12, 13, and 14. Here, the upper trace shows the collector voltage swing and the lower trace shows the waveform at the same point in the circuit with the switch S_1 open. In Fig. 14, at a frequency of 100 kc, the delay in turning OFF because of minority carrier storage is shown. This is a result of operating in the saturated region. If it were desired to operate at this or higher frequencies, the mode of operation would have to be altered to prevent this delay which amounts to 1.2 microseconds.

Conclusions

The method presented consists of two equivalent circuits which represent the transistor in each of the two states which are used in switching operations, i.e., cutoff and saturation. In the cutoff state, both the collector–emitter and the base–emitter junctions present high impedances and may be approximated by open circuits. In the saturated state, the collector–emitter junctions present a low impedance which may be determined from the common-emitter collector characteristic and is designated as R_c. The base-emitter junction in the saturated state presents an impedance which may be approximated by a battery V_f in series with a resistance R_f. These parameters must be determined from the forward base-emitter characteristic for the specified value of collector current in the saturated state.

By means of equivalent circuits, switching circuits may be simplified to contain only linear parameters. These simplified circuits are more easily analyzed and they may disclose improvements which might otherwise be overlooked.

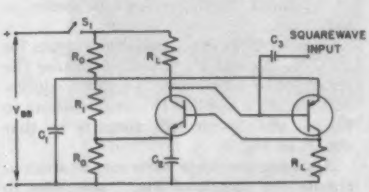

Fig. 12. Bistable circuit p-n-p/n-p-n

Appendix

Calculation of V_{BB}, R_0, R_1, and R_L for p-n-p – n-p-n bistable circuit:

Given equations:

$$\text{(A)} \quad V_{bc} = \frac{V_{BB} R_1}{2\, R_0 + R_1} = 3.0 \text{ volts}$$

$$\text{(B)} \quad I_S = 2 \text{ ma}$$

$$\text{(C)} \quad I_b = 100\ \mu a$$

$$\text{(D)} \quad \Delta V_{CE} = I_C R_L = 5.0 \text{ volts}$$

Values of R_f, V_f, and R_C determined for the particular transistors and the value of I_S chosen:

$R_C = 50$ ohms
$R_f = 300$ ohms
$V_f = 0.2$ volts

Therefore, from equations B and D:

$R_L = 2.5$ *kilohms*

The voltage across the base-emitter junction in the ON state

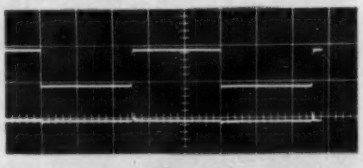

Fig. 13. Circuit operating at 10 kc repetition rate, as seen at n-p-n collector. Vertical scale = 5 volts per major division. Horizontal scale = 20μs per major division.

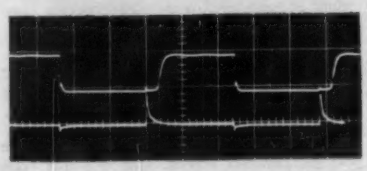

Fig. 14. Circuit operating at 100 kc repetition rate as seen at n-p-n collector. Vertical scale = 5 volts per major division. Horizontal scale = 2 μs per major division.

$= 0.2 + (300)\ (10^{-4})$

$= 0.23$ volts

The voltage across R_e in the ON state

$= 5.0 - 0.23$

$= 4.77$ volts

The current through R_e

$= 2.0 + 0.2 + I_{B_1}$

Therefore $(2.2 + I_{B_1})\ R_e = 4.77$ volts

The voltage across $R_1 = V_{bb} - 9.54$

Therefore $I_{B_1} R_1 = V_{bb} - 9.54$

The voltage across $R_C = V_{bb} - 4.77 - 5.0$

The current through $R_C = I_B + I_b$

$= 2.1$ ma

Therefore $(2.1)\ (R_C) = V_{BB} - 4.77 - 5.0$

$V_{BB} = 9.875$ volts

Therefore, since the voltage across R_1

$= I_{B_1} R_1 = V_{BB} - 9.54$

$= 0.335$ volts

$I_{R_1} = \dfrac{0.335}{R_1}$ ma

Therefore, substituting this value of I_{B_1} in the statement for the voltage across R_e we obtain:

$$\left(2.2 + \frac{0.335}{R_1}\right) R_e = 4.77 \text{ volts}$$

From equation A

$$\frac{9.87\ R_e}{2\ R_e + R_1} = 3.0 \text{ volts}$$

Solving these two equations for R_e and R_1 we obtain:

$R_e = 2.05\ k\Omega$

$R_1 = 2.65\ k\Omega$

References

1. Junction Transistor Electronics, J. L. Moll. *Proceedings* Institute of Radio Engineers, New York, N. Y., Vol. 43 p. 1807.

2. Junction Transistors Used as Switches, AIEE *Transactions* Vol. 74 pt. I, p. 111.

3. Large Signal Behavior of Junction Transistors, *Proceedings* Institute of Radio Engineers, New York, N. Y., Vol. 42 p. 1761.

4. Transistor Circuits for Digital Computers, *Electronics*, New York, N.Y., vol. 29, p. 160.

Electrical Engineering Education

Component Current Method of Circuit Analysis

KENDALL L. SU

IN THE APPLICATION of the mesh analysis method to network problems a question is frequently raised: How should the loop currents be chosen so their independence will always be assured? Several rules may be followed to assure the independence of the set of loop currents. For instance, if a network is flat its mesh currents form a set of independent loop currents. Another scheme that may be followed is to choose the loop currents in such a way that, as each loop current path is traced, it includes at least one new branch that has not been traced before.

Although we are quite accustomed to using loop currents as an independent set of current unknowns in mesh analysis, we should not be misled by this habit to believe that loop currents (of which the use of mesh currents is a special case) must always be used as the unknowns. In many instances, the use of loop currents is convenient. There are also instances in which it is not.

Choice of Independent Current Variables

The only conditions which the choice of a set of current unknowns must satisfy are: (1) these unknowns must form an independent set; (2) the number of independent unknowns should equal the number of degrees of freedom of the network. The number of degrees of freedom in the mesh analysis of a network is $B-(N-1)$, where B is the number of branches and N is the number of nodes. This fixes only the number of unknowns we must use. The manner in which these unknowns are assigned is entirely arbitrary, as long as they are independent. They do not have to be loop currents in the usual sense.

To clarify this point further, let us look at the 3-mesh network of Fig. 1. This network has six branches and four nodes. Therefore, its currents have three degrees of freedom, or exactly three independent current unknowns must be used. It is clear that the three currents designated I_A, I_B, and I_C are independent and, as soon as these currents are found, all other currents may be found without too much trouble. The problem then actually is the finding of these three currents.

However, one may prefer to use mesh currents as current unknowns. If these currents are designated as shown in Fig. 2, the following relationships hold:

$$I_A = i_1$$
$$I_B = i_2 \qquad (1)$$
$$I_C = -i_3$$

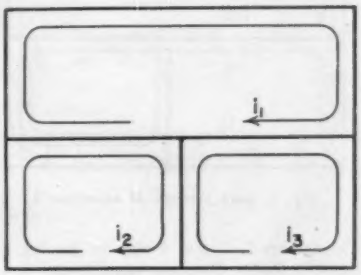

Fig. 2. Mesh currents.

Here the one-to-one relationship between the unknowns and the independent branch currents is obvious. That is to say, whenever i_1, i_2, and i_3 are determined, I_A, I_B, and I_C are also fixed, and vice versa.

If a set of loop currents are chosen as current unknowns, such as that shown in Fig. 3 then we have

$$I_A = i_1$$
$$I_B = i_2 \qquad (2)$$
$$I_C = -i_2 - i_3$$

and the unique relationship between I_A, I_B, and I_C, and i_1, i_2, and i_3, is again established. Therefore, i_1, i_2, and i_3 of Fig. 3 can be used as a set of current unknowns as well.

There are, of course, a variety of ways

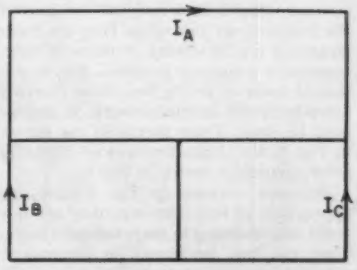

Fig. 1. Network graph.

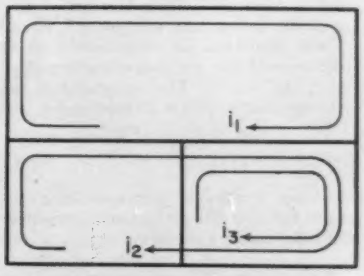

Fig. 3. Loop currents of equations 2.

A special article recommended by the AIEE Educational Publications Committee.

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loop currents may be chosen. Fig. 4 shows another independent set of loop currents. Here

$$I_A = i_1 + i_3$$
$$I_B = i_1 + i_2 \qquad (3)$$
$$I_C = -i_1 - i_2 - i_3$$

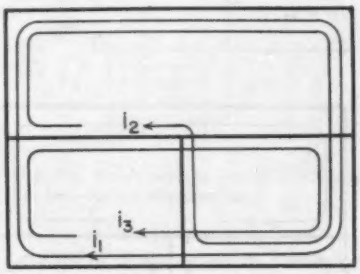


Fig. 4. Loop currents of equations 3.

Equations 1, 2, and 3 may be written in matrix form. They are respectively

$$\begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} = \begin{Vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{Vmatrix} \cdot \begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} \qquad (4)$$

$$\begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} = \begin{Vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & -1 \end{Vmatrix} \cdot \begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} \qquad (5)$$

$$\begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} = \begin{Vmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ -1 & -1 & -1 \end{Vmatrix} \cdot \begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} \qquad (6)$$

In general, they take the following form

$$\|I\| = \|C\| \cdot \|i\| \qquad (7)$$

Insamuch as the branch currents I_A, I_B, and I_C form an independent set of currents, the new current unknowns i_1, i_2, and i_3 will also form an independent set of unknowns if they are uniquely determined by I_A, I_B, and I_C. This is assured if the relating matrix $||C||$ is a nonsingular one. Then the inverse of $||C||$ exists or

$$\|i\| = \|C\|^{-1} \cdot \|I\| \qquad (8)$$

and the one-to-one correspondence between the two sets of currents guarantees the independence of the currents i_1, i_2 and i_3.

Although the $||C||$ matrices in equations 4, 5, and 6 are determined by tracing the loop currents first, they do not have to be obtained in this manner. We can arbitrarily assign any nonsingular matrix for $||C||$ and still maintain the one-to-one relationship between I_A, I_B, and I_C, and i_1, i_2, and i_3. For instance, if we let

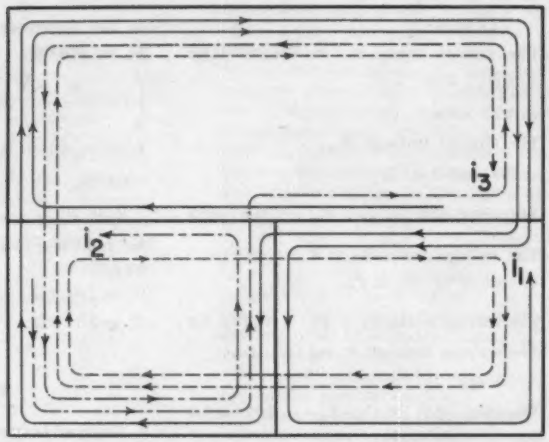


Fig. 5. Component currents of equations 10.

$$\|C\| = \begin{Vmatrix} 2 & -1 & 1 \\ 1 & -2 & 2 \\ 1 & 0 & -2 \end{Vmatrix} \qquad (9)$$

Then

$$I_A = 2\,i_1 - i_2 + i_3$$
$$I_B = i_1 - 2\,i_2 + 2\,i_3 \qquad (10)$$
$$I_C = i_1 - 2\,i_3$$

and

$$i_1 = \frac{2}{3} I_A - \frac{1}{3} I_B$$
$$i_2 = \frac{2}{3} I_A - \frac{5}{6} I_B - \frac{1}{2} I_C \qquad (11)$$
$$i_3 = \frac{1}{3} I_A - \frac{1}{6} I_B - \frac{1}{2} I_C$$

It is clear that i_1, i_2, and i_3 defined this way may be used as a set of independent unknowns.

A natural question will arise at this point: Physically, what do these currents i_1, i_2, and i_3 represent? This is not the point which should be stressed. The important thing is that they *can* be used as the independent unknowns. How the mesh equations can be written in terms of these currents is a separate problem. But, if one should insist on seeing how these currents actually "flow" in the network, it can always be done. Their identities are shown in Fig. 5. An alternative way of dipicting these currents is shown in Fig. 6.

Although currents in Fig. 5 have the appearance of loop currents, they are not really loop currents in their ordinary sense. They can best be termed as component currents.

The numbers assigned to the elements of a $||C||$ matrix need not be limited to integers. Matrix 9 was chosen mainly for the reason that, by its use, all currents may be represented by integral multiples of some basic quantities so that the diagram in Fig. 5 may be drawn.

The numbers assigned to a $||C||$ matrix can certainly be complex as well as real. This may be desirable when the unknowns are, in general, complex. Even if these unknowns are not complex, there is no reason why some of the elements in $||C||$ cannot be complex.

This notion that the variables used in mesh analysis do not have to be some measurable quantities applies to the solution of any physical system. As long as a new set of unknowns is related to an independent set of quantities, they may be used as the unknowns of the system. In the node analysis method, for instance, the node-to-ground voltages are not the only set of variables that we can use as unknowns. The unknowns may be any set of voltages related to a set of independent voltages by a nonsingular matrix $||C||$ in the manner similar to equation 7.

An Application to 3-Phase Circuits

As an example to the notion described, its application to a 3-phase problem is presented here. Fig. 7 shows a general basic 3-phase circuit. It is clear that the three line currents I_A, I_B, and I_C form a set of independent unknowns. When this system is not balanced, this circuit can be treated simply as a general network problem and solved by either mesh or node analysis.

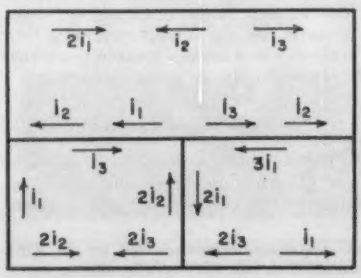


Fig. 6. Alternative way of depicting currents of equations 10.

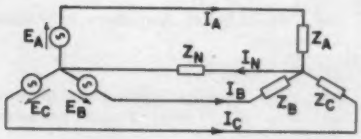


Fig. 7. General 3-phase 4-wire circuit.

Usually, when a 3-phase system is not entirely balanced, there still exists some type of symmetry in the majority part of the network. The solution of these systems can then be simplified to a great extent by using current unknowns other than the line currents. Since there are three degrees of freedom in a network of the type shown in Fig. 7, we must use exactly three current variables. These variables (let them be designated by i_1, i_2, and i_3) must be expressible uniquely in terms of the three line currents I_A, I_B, and I_C, or

$$\begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} = \| C \| \cdot \begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} \tag{12}$$

There is no theoretical limitation as to what $||C||$ should be, as long as it is nonsingular. In practice, a wise choice of $||C||$ may lead to a new set of unknowns, the use of which simplifies the calculations.

In particular, let us denote the three component currents which are related to the three line currents by the matrix

$$\| C \| = \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{Vmatrix} \tag{13}$$

where $a = e^{j120^\circ} = 1/\underline{120^\circ}$, as I_0, I_1, and I_2. It may be found that the determinant of the relating matrix $\| C \|$ is $| C | = j3\sqrt{3}$.

The inverse of $||C||$ is

$$\| C \|^{-1} = \frac{1}{3} \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{Vmatrix} \tag{14}$$

and

$$\begin{Vmatrix} I_0 \\ I_1 \\ I_2 \end{Vmatrix} = \frac{1}{3} \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{Vmatrix} \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} \tag{15}$$

which is the same as the conventional symmetrical component currents.

If the same matrix $||C||$ is used to define a new set of voltages in terms of generator voltages, we have

$$\begin{Vmatrix} E_0 \\ E_1 \\ E_2 \end{Vmatrix} = \frac{1}{3} \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{Vmatrix} \cdot \begin{Vmatrix} E_A \\ E_B \\ E_C \end{Vmatrix} \tag{16}$$

The total complex power delivered by the generators in the circuit shown in Fig. 7 is $P_v = E_A{}^* I_A + E_B{}^* I_B + E_C{}^* I_C$, which is equal to the determinant of the matrix product

$$\| E_A{}^* \; E_B{}^* \; E_C{}^* \| \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix}$$

But

$$\| E_A{}^* \; E_B{}^* \; E_C{}^* \| = \begin{Vmatrix} E_A{}^* \\ E_B{}^* \\ E_C{}^* \end{Vmatrix}_t = \left(\| C \| \cdot \begin{Vmatrix} E_0 \\ E_1 \\ E_2 \end{Vmatrix} \right)^*_t$$

$$= \begin{Vmatrix} E_0 \\ E_1 \\ E_2 \end{Vmatrix}^*_t \cdot \| C \|^*_t = \| E_1{}^* \; E_2{}^* \; E_3{}^* \| \cdot \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{Vmatrix} \tag{17}$$

Hence

$$\| E_A{}^* \; E_B{}^* \; E_C{}^* \| \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix}$$

$$= \| E_0{}^* \; E_1{}^* \; E_2{}^* \| \cdot \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{Vmatrix} \cdot \begin{Vmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{Vmatrix} \cdot \begin{Vmatrix} I_0 \\ I_1 \\ I_2 \end{Vmatrix}$$

or

$$\| E_A{}^* \; E_B{}^* \; E_C{}^* \| \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} = 3 \| E_0{}^* \; E_1{}^* \; E_2{}^* \| \cdot \begin{Vmatrix} I_0 \\ I_1 \\ I_2 \end{Vmatrix}$$

$$= 3 \; (E_0{}^* \; I_0{}^* + E_1{}^* \; I_1 + E_2{}^* \; I_2) \tag{18}$$

Therefore

$$P_v = E_A{}^* \; I_A + E_B{}^* \; I_B + E_C{}^* \; I_C$$
$$= 3 \; E_0{}^* \; I_0 + 3 \; E_1{}^* \; I_1 + 3 \; E_2{}^* \; I_2 \tag{19}$$

The fact that equation 19 turns out to be such a simple expression is a consequence of this particular choice of matrix $||C||$.

Diagonalizing the Impedance Matrix

As another example of this component current concept, let us consider an unbalanced 3-phase circuit of Fig. 7 with the following normalized impedances:

$$Z_N = 0 + j5 \qquad Z_A = 1 + j2$$
$$Z_B = 1 + j3 \qquad Z_C = 1 + j4$$

The matrix relationship for this circuit is

$$\begin{Vmatrix} E_A \\ E_B \\ E_C \end{Vmatrix} = \begin{Vmatrix} (1+j7) & j5 & j5 \\ j5 & (1+j8) & j5 \\ j5 & j5 & (1+j9) \end{Vmatrix} \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} \tag{20}$$

It is clear that if the symmetrical component transformation is used on these currents and voltages, nothing is gained. It only changes the problem to another that is just as involved.

However, if we choose current and voltage variables in such a way that they are related by a diagonal matrix, then component currents can be related to component voltages in a very simple fashion. This would simplify the computation a great deal, especially when a great number of voltage and current sets are to be calculated. This can be achieved by letting

$$\begin{Vmatrix} e_1 \\ e_2 \\ e_3 \end{Vmatrix} = \begin{Vmatrix} 1 & 0 & 0 \\ \left(-\frac{7}{10} - j\frac{1}{10}\right) & 1 & 0 \\ \left(-\frac{7}{15} - j\frac{1}{15}\right) & -\frac{1}{3} & 1 \end{Vmatrix} \cdot \begin{Vmatrix} E_A \\ E_B \\ E_C \end{Vmatrix} \tag{21}$$

and

$$\begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} = \begin{Vmatrix} 1 & \left(-\frac{7}{10} - j\frac{1}{10}\right) & \left(-\frac{7}{15} - j\frac{1}{15}\right) \\ 0 & 1 & -\frac{1}{3} \\ 0 & 0 & 1 \end{Vmatrix}^{-1} \cdot \begin{Vmatrix} I_A \\ I_B \\ I_C \end{Vmatrix} \tag{22}$$

Equation 20 now becomes

$$\begin{Vmatrix} e_1 \\ e_2 \\ e_3 \end{Vmatrix} = \begin{Vmatrix} (1+j7) & 0 & 0 \\ 0 & (1.5+j4.5) & 0 \\ 0 & 0 & \left(\frac{4}{3}+j5\right) \end{Vmatrix} \cdot \begin{Vmatrix} i_1 \\ i_2 \\ i_3 \end{Vmatrix} \tag{23}$$

which is the desired form.

In general if

$$\| E \| = \| Z \| \cdot \| I \| \tag{24}$$

$$\| E \| = \| C_1 \| \cdot \| e \| \tag{25}$$

$$\| I \| = \| C_2 \| \cdot \| i \| \tag{26}$$

then

$$\| e \| = \| C_1 \|^{-1} \cdot \| Z \| \cdot \| C_2 \| \cdot \| i \| = \| z \| \cdot \| i \| \tag{27}$$

where

$$\| z \| = \| C_1 \|^{-1} \cdot \| Z \| \cdot \| C_2 \| \tag{28}$$

It is seen, then, that $||C_1||$ and $||C_2||$ of equations 25 and 26 should be so chosen that $||C_1||^{-1}$ and $||C_2||$ diagonalize the impedance matrix $||Z||$. If $||C_1|| = ||C_2||$, then the transformations used for voltages and currents are the same. The computation of $||C_1||$ *and* $||C_2||$ for a given $||Z||$ is a routine matter in matrix algebra.

Conclusions

The examples given show that the concept of component current variables can

be used to good advantage in simplifying specific problems. The transformation that is suitable for a problem depends on the particular problem at hand. Its success depends largely on finding the proper transformation matrix. To this end, the theory of matrix algebra should answer all needs.

These examples also serve to show that the conventional symmetrical component method is a very special choice of transformation and, in general, is only suitable to some very special form of polyphase problems. In this context, the importance of the symmetrical component method should not be overemphasized.

Results of the District Student Papers Competition

THE WINNERS of the AIEE District Student Prize Papers Competition have been announced.

In addition to the $25 Institute award to each first prize winner in the District, the Members-for-Life Fund has provided additional prizes which include a trip to the Summer General Meeting for the first prize winners, $25 for second prize, and $15 for third prize.

The following students are the recipients of these awards.

District No. 1

1. M. W. Musbach, Union College, "Communications System for Scuba Divers."

2. David Gross, Rensselaer Polytechnic Institute, "A Liquid Level Senser."

3. W. H. Leipold, University of Buffalo, "The Logic Circuit Simulator."

District No. 2

1. I. E. Sutherland, Carnegie Institute of Technology, "Parallels, Men, and Machines."

2. Azatollah Farokhrooz, Lafayette College, "The Distribution of Current along Center Fed Cylindrical Antennas."

3. C. W. Hardy, Johns Hopkins University, "Operational Amplifiers in Analog Computors."

District No. 3

1. Peter Hirsch, Polytechnic Institute of Brooklyn, "Linear Phase Transistor Amplifiers."

2. Saul Walker, New York University, "A Complementary Symmetry Multivibrator."

3. A. R. Lopez, Manhattan College, "A Unique Analysis of a Half Wave Diode Rectifier."

District No. 4

1. Copthorne Macdonald, University of Kentucky, "A Slow-Scan TV System for Image Transmission."

2. W. E. Montgomery, Duke University, "An Electronic Microscope."

3. B. W. Daugherty, V. E. Rochat, University of Tennessee, "The Passive Analog Computer."

District No. 5

1. J. A. Lauder, University of Michigan, "An Electronic Random Number Generator."

2. R. F. Green, Marquette University, "Nuclear Batteries."

3. Paul Scheibe, University of North Dakota, "Phase-Locked Oscillator Systems as Applied to Double Sideband Suppressed Carrier Communications."

District No. 6

1. A. P. Wilson, South Dakota School of Mines and Technology, "Two Variable Comparison with Factorial Experimentation as Applied to the Static Characteristic of a Transistor."

2. P. G. Bernard, University of Nebraska, "Toward a Universal Test of Vacuum Tubes."

3. P. C. Callan, South Dakota School of Mines and Technology, "An Amplidyne Voltage Regulator."

District No. 7

1. J. R. Cox, Texas A & M College, "Grid Current Measurements with a D-C Analog Computer."

2. D. C. Watkins, Rice Institute, "Investigation of Unstable Linear Networks by the Application of Feedback Techniques."

3. D. P. Maragni, University of St. Louis, "Methods of Load Forecasting."

District No. 8

1. A. R. Wilson, R. A. Mintz, California State Polytechnic Institute, "A Serial Binary Adder for a Digital Computer."

2. R. D. Young, University of Arizona, "A Passive Reactance Modulator."

3. Douglas MacMillian, University of California (Berkeley), "Oscillatory Characteristics of a Saturable Reactor."

District No. 9

1. D. B. Ulm, Myron Hurlbut, Oregon State College, "Effects of Phase Shift Between Applied Voltages of a Magnetic Amplifier."

2. W. S. Perkes, N. C. Rigby, University of Utah, "A Small Relay Digital Computer."

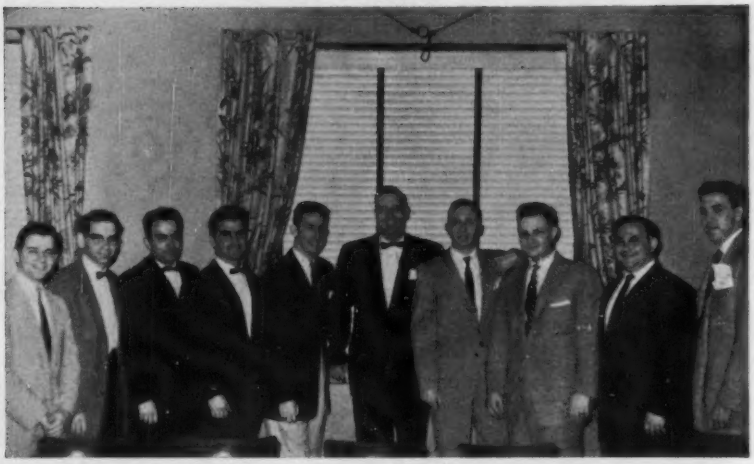
3. G. A. Rodeman, Washington State College; Richard Daniel, University of Alaska; W. T. Booth, Montana State College.

Student Paper Winners at Summer Meeting

Photography by The Towne Studio

DISTRICT STUDENT PRIZE PAPER WINNERS who attended the Summer General Meeting of the AIEE in Buffalo, N. Y., June 22-27, 1958, at the Statler-Hilton Hotel. In addition to winning $25 for their papers, they also were awarded an expense paid trip to the Summer Meeting. Seated (*left to right*) are: C. J. Grimm, Missouri School of Mines, student counselor; A. R. Wilson and R. A. Mintz, California State Polytechnic Institute; R. J. Doyle, Northeastern University; and Copthorne Macdonald, University of Kentucky. Standing (*left to right*) are: J. R. Cox, Texas A&M College; M. R. Hurlburt, Oregon State College; and A. P. Wilson, South Dakota School of Mines & Technology.

NYU Prize Paper Winners



NEW YORK UNIVERSITY's past prize paper winners hold surprise reunion at the fourth annual Student Prize Paper Contest sponsored jointly by AIEE District No. 3 and Institute of Radio Engineers Region No. 2, April 25, 1958, on the campus of NYU. Past and present winners are: (left to right) Richard Wolfson, 1955 third prize; S. A. Walker, 1958 second prize; Nicholas Kfoury, 1957 first prize; Howard Cohen, 1957 third prize; C. A. Von Urff, 1956 first prize; J. H. Mulligan, Jr., chairman of the department of electrical engineering; Harold Gordy, 1956 third prize; R. A. Fisch, 1958 fourth prize; Stanley Burmil, 1958 fourth prize; and Arvin Grabel, 1955 first prize and 1955 AIEE National Prize Paper Contest second prize.

District No. 10 (No Contest)

District No. 11

1. W. C. Susor, University of Toledo, "Design of Nuclear Reactor Simulator for Control System Testing."
2. R. A. Thompson, R. G. Tomlinson, Case Institute of Technology, "Polarization Studies of Satellite Signals."
3. P. L. Klingenmeier, University of Cincinnati, "Design and Construction of a Variable Bandwidth I.F. Filter."

District No. 12

1. Robert Doyle, Northeastern University, "Cathode-Ray Tube Gun Design for Storage Tube Application."
2. J. C. Sethares, University of Massachusetts, "A Voice Operated Typewriter."
3. D. H. Wordell, Bradford-Durfee Technical Institute, "Solutions for Absolute Inequalities."

District No. 3 Prize Paper Contest

Over 350 students attended the fourth annual joint AIEE District No. 3–Institute of Radio Engineers (IRE) Region No. 2 Student Prize Paper Contest on April 25 at New York University. Peter Hirsch of Polytechnic Institute of Brooklyn (Day Division) brought top honors to his school with his paper "Linear Phase Transistor Amplifiers."

The second prized went to S. A. Walker of New York University (Evening Division) for his paper "A Complementary Symmetry Multivibrator." Third prize was taken by A. R. Lopez of Manhattan College for his paper "A Unique Analysis of a Halfwave Diode Rectifier." A pair of New York University (Day Division) students, Stanley Burmil and R. A. Fisch received fourth prize for their paper "Design of an Uncompensated, Multistage, Resistance Coupled, Wide-Band Amplifier To Exhibit Maximum Bandwidth and Minimum Rise Time for a Specified Time."

Through the generous co-operation of the New York Sections of AIEE and IRE,

STUDENT WINNERS of the 1958 AIEE District No. 3–IRE Region No. 2 Prize Paper Contest are: (left to right) R. A. Fisch and Stanley Burmil, fourth prize; A. R. Lopez, third prize; Peter Hirsch, first prize; and S. A. Walker, second prize.

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Mr. Hirsch's prize included a $500 Scholarship for graduate study. The other three prizes were in cash in the amounts of $100, $50, and $25, respectively. In addition, each of the prize winners and their counselors were guests of International Business Machines Corporation for an inspection trip to their Poughkeepsie and Kingston, N.Y., plants.

AIEE District No. 4 Annual Student Conference

The annual Student Conference of AIEE District No. 4 was held April 16-19, 1958, on the campus of Duke University.

The Conference began with registration on Wednesday, April 16, followed that night by an open house in the laboratories of the department of electrical engineering. Each laboratory was staffed by one or more students who had set up a display using the laboratory equipment.

The program for April 17 consisted of a papers session in the morning and a field trip in the afternoon which included inspection of the Westinghouse Meter Plant in Raleigh, N. C., a tour through the campus of North Carolina State College, and a special show at the Morehead Planetarium at the University of North Carolina, Chapel Hill, N. C.

The program for April 18 included a morning paper session with field trips to the Liggett and Myers Tobacco Co. Chesterfield plant and the Wright Machinery Division of the Sperry-Rand Corporation,

both of which are located in Durham, N. C. During the banquet held that evening, Dr. P. M. Gross, vice-president of Duke University, spoke on "The Engineer and the New Scientific Era." Prof. Claudius Lee of Virginia Polytechnic Institute (VPI) spoke briefly on his long experience as a counselor. Prof. Lee joined VPI in 1893 and has been a counselor of the student branch there since 1916. He is still working part time and serving actively as counselor. At the conclusion of the banquet, the prize winning papers were announced. First place went to Copthorne Macdonald, University of Kentucky, for his paper "A Slow-Scan TV System for Image Transmission." Second place winner was W. E. Montgomery, Duke University, for his paper entitled "An Electronic Microscope." Third place paper, delivered by B. M. Daugherty and V. E. Rochat, University of Tennessee, was entitled "The Passive Analog Computer." Honorable Mention went to Carolyn M. Campbell, Louisiana State University; J. A. Bryant and W. K. Fikes, University of Alabama; C. N. Causey and R. D. Benton, Mississippi State College; and P. W. Koetsch, University of South Carolina.

Following the banquet, a dance was held on the Women's College Campus of Duke University.

Final business was the counselors' meeting on Saturday morning, April 19, during which the students held a group dynamics session on topics relating to Conference and Branch activities. The Georgia Institute of Technology invited the group to meet in Atlanta, Ga., in Spring 1959 in connection with the regular District Conference.

The total registration at the 1958 Student Conference was 325, including guests and AIEE officials. J. W. Rittenhouse, outgoing chairman of the Student Branches Committee, was present for several of the events and spoke to the students during the Saturday morning session. B. V. Martin represented District No. 4 as secretary.

Tremendous credit goes to all of the students of the Duke University Branch of the AIEE, particularly the officers: J. W. Redmond, chairman; J. E. Jenkins, vice-chairman; T. C. Stapleford, treasurer; and W. J. Steinmetz, secretary; as well as others carrying major responsibilities for field trips, banquet, housing, etc.: R. W. Barnes, R. B. Brownell, L. J. Jones, F. S. Lewis, D. C. Tipton G. L. Van Curen, E. E. Bulkley, J. W. Lintzenich, and C. B. Schafer.

WINNERS of the 1958 Student Conference Paper Contest for District No. 4, shown outside the Engineering Building on the campus of Duke University, are: *(left to right)* V. E. Rochat, University of Tennessee, third place; R. D. Benton, Mississippi State College, P. W. Koetsch, University of South Carolina, and Carolyn Campbell, Louisiana State University, all honorable mention; Copthorne Macdonald, University of Kentucky, first place; W. E. Montgomery, Duke University, second place; C. N. Causey, Mississippi State College, honorable mention; and B. M. Daugherty, University of Tennessee, co-author with Mr. Rochat, third place.

COUNSELORS AND STUDENTS gather in front of the Student Union at the University of Arkansas, Fayetteville, during the AIEE District No. 7 Student Prize Paper Contest, held April 23-25, 1958.

AIEE District No. 7 Student Paper Contest

The University of Arkansas Joint Student Branch of AIEE–IRE (Institute of Radio Engineers) was host to visiting schools from AIEE District No. 7 for the 1958 District Student Paper Contest held on the University campus at Fayetteville, Ark., on April 23-25, 1958.

Some 95 students and faculty members representing 20 of the 22 schools in the District registered for the meeting. Papers were presented by students from 19 schools with the winners in the contest as follows: first place went to J. R. Cox, Texas A&M, for a paper entitled "Grid Current Measurements with a D-C Analog Computer"; second place to D. C. Watkins, Rice Institute, for a paper entitled "Investigation of Unstable Linear Networks by the Use of Feedback Techniques"; and honorable mention to D. P. Margani, St.

TWO WINNERS in the District No. 11 Student Prize Paper Competition tour the radio telephone transmitter room of the Ohio Bell Telephone Company, Cleveland. Shown (*left to right*) are: Floyd Knapp, chief engineer; R. G. Tomlinson, Case Institute of Technology; and W. C. Susor, University of Toledo.

Louis University, for his paper entitled "Methods of Load Forecasting." Special mention for the best oral presentation was given to J. V. Locasso, Oklahoma State University, who spoke on "The Electrical System of the Human Body."

Activities began with a "kick-off" banquet on Wednesday, April 23, during which Dr. J. T. Caldwell, president of the University of Arkansas, was the principal speaker. N. F. Rode, vice-president of AIEE District No. 7, spoke on the engineering societies building program. The Northwest Arkansas Subsection members were special guests at the banquet which was well attended by local students as well as visiting students.

Paper sessions were held on Thursday morning and afternoon and on Friday morning. Pi Delta Wye, honorary electrical engineering fraternity, sponsored refreshments for the "coffee break" during the paper sessions. Speakers, incoming chairmen, and Branch counselors attended a luncheon on Thursday with C. J. Grim, vice-chairman of the AIEE Student Branches Committee as guest. Mr. Grim spoke to the luncheon group and also to the chairmen and counselors at their respective meetings held in the afternoon.

The meeting closed with an awards luncheon at the A. Q. Chicken House in Springdale, Ark., at which time the winners were announced by Delbert Schmand, U.S. Corps of Engineers, who was chairman of the judges committee. Principal speaker was R. J. Rhinehart, past-president of the National Society of Professional Engineers.

AIEE District No. 11 Student Paper Competition

The Student Prize Paper Competition for District No. 11 of AIEE was held at the University of Toledo on May 3. The following five papers were presented: "Design and Construction of a Variable Bandwidth I-F Filter," by P. L. Klingenmeier, University of Cincinnati; "Frequency Division for Multispeaker Audio Reproduction," by R. L. Gleason, Fenn College; "Ballasts for Fluorescent Lamps," by G. B. King, University of Akron; "Polarization Studies of Satellite Signals," by R. A. Thompson and R. G. Tomlinson, Case Institute of Technology; "Design of a Nuclear Reactor Simulator for Control System Testing," by W. C. Susor, University of Toledo.

The Judges provided by the AIEE Toledo Section were: A. Hoefle, chief electrical engineer, Toledo Edison Company; D. B. Kendall, electrical engineer, Toledo Scale Company; D. L. Rexford, International Business Machines Corporation; Paul Thornberry, electrical engineer, Westinghouse Electric Corporation; Richard Warren, Libby-Owens-Ford Glass Company; and Vern Politsch, Owens-Illinois Glass Company.

Three judges reviewed the papers and the other three judged the oral presentation. Their selections were: first—Mr. Susor; second—Mr. Thompson and Mr. Tomlinson; and third—Mr. Klingenmeier.

After a tour of the University laboratories, those in attendance were dinner guests of the Toledo Section and the District in the University cafeteria.

At the dinner, the winners were awarded small cups, replicas of the District Cup which will be held by the University of Toledo for the next year. Vice-President H. H. Kerr congratulated the

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District No. 8 Prize Paper Winners

ELECTRICAL ENGINEERING STUDENTS from five colleges and universities presented technical papers in the student paper competition sponsored by AIEE District No. 8 at the University of Arizona on May 10, 1958. Pictured (*front row, left to right*) are: Douglas MacMillan, University of California at Berkeley, who placed third; R. A. Mintz and A. R. Wilson of California State Polytechnic College at San Luis Obispo, co-authors of the paper awarded first prize of $25 from District No. 8 and $25 from AIEE national headquarters, plus a $50 special award from Daly Electric Company of Phoenix, Ariz., and a trip to Buffalo, N. Y., to attend the AIEE Summer General Meeting June 22-27; Wayne Smith, University of Southern California; W. E. Baker, Arizona State College at Tempe; and R. D. Young, University of Arizona, who placed third. In rear row are O. A. Gustafson (*left*), vice-president, District No. 8, who is with the General Electric Company's San Francisco office; and Prof. J. L. Knickerbocker of the University of Arizona electrical engineering department, and faculty adviser to the Student Branch of AIEE and Institute of Radio Engineers.

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winners and the incoming Vice-President, Warren Chase, invited the winners and their counselors to visit the Cleveland plant of the Ohio Bell Telephone Company. President Asa Knowles of the University of Toledo was the guest speaker.

The meeting was closed with the showing of a travel movie by the outdoor editor of the Toledo Blade.

AEC Grants To Aid Nuclear Technology Training

L. L. Strauss, chairman of the Atomic Energy Commission (AEC), has announced approval of grants totalling $1,900,321 to 41 American colleges and universities to be used to expand facilities for training nuclear scientists and engineers. These grants are part of the AEC's program to help in avoiding a shortage in future years of trained manpower in the atomic energy field.

The funds will be applied by the recipients toward the purchase of laboratory equipment needed to broaden nuclear science and engineering curricula.

These awards, the fourth in a series under this program, bring to $8,664,709 the total alloted to 95 educational institutions. More than 120 applications have been received since the AEC's policy was announced in September 1956.

Cornell University, Iowa State College, Stanford University, and Worcester Polytechnic Institute were each awarded $150,000, the largest individual grants.

The awards provide for small teaching reactors at six educational institutions: Cornell University, Iowa State College, University of Kansas, Stanford University, Virginia Polytechnic Institute, and Worcester Polytechnic Institute. A total of 23 awards have been made for teaching reactors at colleges and universities under this program. The institutions are required to obtain licenses to operate the reactors.

Grants for the purchase or construction of nuclear reactors for science and engineering education are made to colleges or universities which conduct studies in nuclear energy technology at the graduate level and are accredited by the Engineers' Council for Professional Development.

In addition to making grants, the AEC has also made loans without charge to colleges and universities of nuclear materials, such as uranium metal for reactor fuel and neutron sources for subcritical assemblies.

The AEC also supports fellowships, finances research projects at colleges and universities, and operates a number of training programs in nuclear technology for students and teachers.

MIT Announces Center for Communication Sciences

ESTABLISHMENT of a Center for Communication Sciences at the Massachusetts Institute of Technology (MIT) has been announced by Dr. J. A. Stratton, acting president.

Studies of the communication functions of the nervous system and of such machines as computers, as well as of methods of communication between the two, will be conducted in the new Center by a group of scientists and engineers, some of whom have been engaged in such research for several years. The Center will use the facilities of the Research Laboratory of Electronics (RLE), where there has been a concentration of interest in this field.

The Center will be under the direction of a steering committee composed of Dr. J. B. Wiesner, director of the RLE; Dr. C. E. Shannon, who is one of the originators of the mathematical theory of communication; Dr. G. S. Brown, head of the department of electrical engineering; Dr. R. M. Fano, a communications engineer specializing in information theory; Dr. Roman Jakobson, one of the world's outstanding linguists; and Dr. W. A. Rosenblith, a biophysicist with a special interest in sensory communications.

MIT scientists have long been active in fields included in communication sciences. Dr. Vannevar Bush, now chairman of the corporation, was a pioneer in work on computers. Dr. Norbert Wiener, a mathematician, is the father of studies known as Cybernetics, which relate to human and machine communications systems. Dr. Shannon, who did his graduate work at MIT, was on the staff of Bell Telephone Laboratories for a number of years, and then returned to MIT, is recognized throughout the world as an authority on information theory.

"The pioneering successes of Vannevar Bush, Norbert Wiener, and Claude Shannon and of their associates raised many hopes and have been responsible for establishing MIT's international reputation in a broad field that is now becoming known as 'the communication sciences'," Dr. Stratton said in his announcement.

Scientists and engineers have become increasingly aware of two needs: how to relate man effectively to the devices that he has to operate and how to match informationally their inputs and outputs with his capacities. In the new center, we hope it will be possible to advance into challenging new areas of research."

To a certain extent, activities which will be included in the new Center can be traced back to the MIT Radiation Laboratory which, during World War II, was responsible for development of radar. After the war, the RLE was established to continue research work in related fields on a peacetime basis. Staff members of the laboratory have worked on a large number of problems, but increasing interest in the communication sciences has resulted in the activity of researchers from fields not commonly associated with electrical engineering, such as psychology, physiology, and linguistics.

Techniques and theories developed in the RLE were crucial to a new concept of continental defense, and MIT established and operates Lincoln Laboratory for the Armed Services in applying this concept. The result has been the SAGE system, a network using radar, new communications methods, and computers for prompt detection of enemy aircraft, immediate analysis of battle situations, and instant response by weapons.

The Center for Communication Sciences will be concerned chiefly with basic research having no direct military application, according to Dr. Wiesner, but the SAGE system provides an example of the extreme complexity of the field in which its people will work.

"This elaborate system was devised by men, but we still do not fully comprehend how such a system operates in man himself—how he analyzes the information he collects about his environment," Dr. Wiesner said. The eyes, ears, nose, and other sense organs gather data and this data is analyzed in the nervous system on a scale enormously more complicated than that of the SAGE system.

"It has been estimated that there are about 10 billion cells in a human being which can be used in obtaining, storing, and using information. We know that the highly elaborate patterns in the electrical activity of these cells are related to the processes which we call seeing, listening, and undoubtedly also to the even more complex processes of learning, thinking, and memorizing. We have a good deal of knowledge about how the nervous system behaves, but our knowledge is still far from complete.

"Nor do we understand how to exploit the full potentialities of machines. We build computers which analyze data faster than we can use the answers. Man can't think rapidly enough to keep up with them. On the other hand, computers are not sufficiently flexible to be as useful as they could be. They have to be told how to solve problems, and this takes a great deal of man's time.

"We believe that collaborative work between mathematicians, electrical engineers, linguists, psychologists, physiologists, and others should lead to a new understanding of communications and to more effective use of machines."

As a small example of the kind of problem to be dealt with in the Center, Dr. Wiesner pointed out how a telephone number is communicated as a unit of information. People can remember a number more easily when it has a word as a prefix, as in the case of the MIT number:

UNiversity 4-6900

The dial system, however, is not "interested" in the word and will accept the number just as readily if dialed as:

864-6900

A computer, using the binary system, would accept the number only when coded in these terms:

1000110101000110010100

Such a number would be very difficult for a human being to learn, though remembering it would be greatly facilitated by "recoding" it, or breaking it down into groups as:

1 000 110 101 000 110 010 100

This trivial example, Dr. Wiesner said, indicates one of the differences in the way that machines and people communicate. Further research should make possible a better understanding of their methods of communication and may result in greater efficiency of both.

As a slightly more complicated example, Dr. Wiesner offered an imaginary incident in which one sees a man approaching on the street. More efficiently than the biggest computer, the nervous system analyzes his gait, size, coloring, facial features, dress, and age (and, if you were a dog, his smell) and concludes that the man is McLean (but not MacLean, McClaine, Macklain, McClain, or McCleane) whose first name is John and who loaned you $5 on the Fourth of July in 1953.

"To reach this conclusion, distinguishing the man from Jones or Smith or Wiesner or Wiener, a great many things happen very rapidly in the sense organs and in the associated nervous system and its billions of cells," Dr. Wiesner said. "Pathways to the brain have been mapped by researchers and some progress has been made in describing man's behavior and neural phenomena in mathematical terms.

"So much research has been done that many uncorrelated facts exist about the performances of people and of machines. We need generalizations and theories which will account for intellectual processes in detail." More specifically, Dr. Wiesner said, the Center would like to get satisfactory answers to questions such as:

Can we describe in mathematical form the grammar of a language, such as English or Russian?

Can we give a rational account of the way in which man's brain processes the information coming through his senses about the world around him?

What role does information play in human learning and decision-making? Are there laws to be discovered which resemble the laws of physics in their generality and predictive power?

Among the experimental studies that have been carried out by people in the Communication Sciences group are ones dealing with: (1) translation of languages by machine; (2) electronic devices for aiding the blind and deaf; (3) synthesis of human speech; (4) compression of speech, eliminating all aspects except those which carry essential meaning; and (5) analysis of electrical activity of the brain by electronic computers.

Northwestern University Technological Institute

The electrical engineering department of the Northwestern University Technological Institute has been awarded a 1-year contract for research in the dielectric and piezoelectric effects in zinc and cadmium sulfide by Wright Air Development Center, Dayton, Ohio.

Principal investigator is Dr. Rudolf Frerichs, who has done extensive work in semiconductors, dielectrics, and ferromagnetics. The study involves expenditure of about $30,000.

In probing the electrical fields and optical properties of zinc and cadmium sulfide crystals, the researchers will investigate the dielectric constants of the materials as functions of temperature, utilizing the low extreme of liquid helium up to a temperature of 1,000 C and frequencies up to microwave level.

Other aspects of the research will involve piezoelectric effects as a function of temperature and crystal orientation, optical-electrical effects, dielectric constant, and dielectric loss as a function of the deviation of the crystals from stoechiometric equilibrium.

Another phase will be investigation of the influence of light as well as that of penetrating radiations from x-rays, and beta and gamma rays, on the dielectric properties of the crystals. A new 1,200 square foot laboratory, equipped for research in fundamental processes associated with solid-state phenomena has been developed at Northwestern by Dr. Frerichs.

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An Electrical Engineer in Education

W. J. SEELEY (AM '19, F '45, Member for Life), dean, College of Engineering, Duke University, Durham, N. C.

"For seniors, the last semester in college is the time when momentous decisions are to be made—it is a time when one chooses the first step in a lifelong career. Selecting a company and a job are serious matters indeed, and this selection cannot be taken lightly. This season, then, is one of many conferences with interviewers, teachers, parents, wives; of sleepless nights, days of indecision, some groping, and much soul searching.

"Intuitively, most young men seek a life of service—service to themselves and family, to country, and ultimately to fellow man. The circuits for that service are many; some are indirect, as through the mechanisms of an engineering organization or manufacturer, where the engineer achieves his ultimate goal through synchronized co-operation with other men and production machines; some are more direct, as through the work of a public utility organization furnishing power and communication service to industry and homes; some are still more direct, as through the profession of teaching.

"Teaching is the most persistent and consistent profession of mankind. There is no greater profession on earth. One teaches throughout one's lifetime, from a child teaching his younger brother, and parents teaching their children, to worker teaching fellow worker, a continuing process of the older ones passing something of themselves on to the younger. In this process, each one of us touches immortality, directly or indirectly, consciously or unconsciously, by leaving vestiges of ourselves in the development of others. Through this we live far beyond our allotted span of mortal years; aspects of our character and personality are passed on to posterity. Through this we find our ultimate destiny, our reasons for being, for populating this earth. Indeed, a teacher lives in those who come after him—he is immortal.

"Engineering teaching is a rewarding and satisfying profession, to which a serious look should be given when choosing a career. There is nothing more rewarding than to see the light of understanding shine in another's eyes where no light shone before, to see the unfolding of an intricate process as it becomes clear and ultimately part of the mental equipment of the student. The feeling of being a humble instrument in the process of another person's development is most gratifying; living in another being, contributing to his character and personality, fills one with gratitude and love. It counterbalances all the drudgery, heartaches, and sacrifices which are part of a worthwhile profession. A profession of service is a sacrificial profession, requiring the projection of one's self into the difficulties of the other, but in larger measure it is a gratifying profession, one in which you see yourself grow in others.

"Unfortunately, the profession suffers

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from a deprecatory attitude on the part of practitioners, a long nurtured feeling of economic inferiority. True, economic stress has been experienced, it is a contribution for participation in the profession, but it does not result in the sheer poverty that some would like you to believe. Teachers own their own homes, own automobiles, educate their children, and otherwise enjoy normal comfort. For the most part, they do not live lavishly, but they do live respectably. Over and against apparent economic stress must be set a number of other not inconsiderable factors: opportunities to augment income and experience through consulting practice, opportunities to augment income and cation of original discoveries, the writing of books, professional prestige, and life in a cultural community.

"The teacher is a man of stature in his profession; he is looked up to and respected, not just because he teaches but because he must first know before he can teach and is, therefore, considered to be fundamentally well grounded. He is sought out for professional services in research, consultation, and practice. He is a much sought after personage in professional societies and committee assignments. He enjoys unusual prestige in the professional community—he is respected, admired, and envied. Engineering is that profession which makes life better for more people; it is a profession of service, and to teach in that profession is to devote one's energies to an immortal cause for the betterment of fellow man.

"Our greatest natural resource is human brains, and education is the most important factor in human evolution. To be engaged in a facet of that process, in spite of its economic limitations, is to devote one's self to the greatest profession on earth. And of all teaching, engineering teaching brings the satisfaction of contributing to an ever growing standard of living for our fellow man."

Dean Seeley has been a member of the faculty of Duke University since 1925, and dean of the College of Engineering since 1953. He has been active in consulting work for industry and Government and, at present, is consultant for the Duke Power Company.

A senior member of the Institute of Radio Engineers, Dean Seeley is also a member of Engineers' Council for Professional Development, American Society for Engineering Education, National Society of Professional Engineers, Sigma Xi, Tau Beta Pi. He is a registered professional engineer in the State of North Carolina.

As an active member of the Institute, he has served as AIEE vice-president, 1949-51, as chairman of the North Carolina Section of the AIEE, 1936-37, and as a member of the following Institute Committees: Student Branches (1932-33), Research (1937-40), Basic Sciences (1945-50), Science and Electronics Co-ordinating (1949-50), Code of Principles of Professional Conduct (1953-54), Education (1954-57), Management (1954-58), Lamme Medal (1956-59), Administration Department (1956-57), and Recognition Awards (1957-58).

Survey of Technical Institute Enrollment

America's "technical institutes"—institutions of higher education with programs of less than 4 years' duration—graduated 11,742 students from engineering-related curricula during 1956.

These graduates were qualified for hard-to-fill technical positions in industry, where many of them might relieve professionally trained engineers for more creative, advanced assignments.

Total enrollment in engineering-related "technical institute" curricula was 32,498 full-time and 25,124 part-time students in 1956. Of these, 15,491 full-time and 10,646 part-time students were enrolled for the first time during the year.

These figures, covering 200 schools, of which 31 have at least one curriculum accredited by Engineers' Council for Professional Development, are the result of the first survey of "technical institute" enrollments ever made by the American Society for Engineering Education (ASEE) and the U.S. Office of Education.

Urged by the President's Committee on Scientists and Engineers, the ASEE and Office of Education undertook the project "because of the importance of the programs in helping to meet national manpower shortages."

The authors of the report, Dr. H. H. Armsby and Dr. S. V. Martorana of the Division of Higher Education in the Office of Education, call the results "encouraging from the manpower standpoint."

"Both total and first-time enrollment of full-time students is considerably larger than that of part-time students. The full-time students represent prospective additions to the labor force, whereas the majority of part-time students are already employed and do not represent new talent."

Noting that there are no comparable statistics for previous years, the authors call this survey the first of an annual series which "can be expected to show developments and trends with important manpower implications."

WPI Produces Model of Niagara Falls Project

One of the biggest projects in the 64-year history of the Worcester Polytechnic Institute (WPI) Aldcn Hydraulic Laboratory is in progress in the woods of Holden.

It will reproduce by model, on a scale of 1 to 50, part of the $700 million project to harness water for power at Niagara Falls, N. Y. The L-shaped model is nearly 600 feet long. It extends far beyond the previous testing area of the sprawling labs. Construction began in May and, it is hoped by Director L. J. Hooper, will be completed early in September. Then will begin several months of experimentation.

The Niagara Falls project will take in water above the falls, run it more than four miles in twin 46- by 66-foot conduits under the City of Niagara Falls and dump it into a canal. The canal, running at right angles to the conduits, will carry the water nearly a mile to a projected Lewiston power station on the river below the Falls.

By dropping the water 300 feet to 13 mammoth turbines, electric power will be generated. The canal will be open, 500 feet across and 50 feet deep.

A reservoir for water storage, about four square miles, will be at the other end of the canal. The reservoir and canal will be separated by the Tuscarora power station to pump water into and out of the reservoir.

The New York State Power Authority is spending $100,000 to check by model the effects of the system when flow of water in the Lewiston or Tuscarora stations is stopped, started, speeded, or slowed.

The answers will come out of WPI's hydraulic testing laboratory in Holden.

Hughes Fellowships Awarded to 51 AIEE Student Members

Some 51 collegiate members of the AIEE from 35 colleges and universities have been awarded Hughes Master of Science Fellowships enabling them to take graduate study leading to master's degrees while earning salaries at Hughes Aircraft Company plants.

The 51 AIEE winners are among a total of 136 recipients of Hughes M.S. Fellowship Awards for 1958. The group represents 37 states and Hawaii.

More than 550 students have received Hughes M.S. Fellowships since the program was activated in 1952.

Hughes designs and manufactures electronic armament control systems for U.S. Air Force jet interceptor airplanes, several types of Falcon air-to-air guided missiles, radar ground systems, and commercial products such as cathode-ray storage tubes, several kinds of semiconductors including transistors, and electronic controls for machine tool lines. Other fields of activity include digital computers, microwave devices and antennas, radomes and precision plastics, communications systems, and miniaturization.

The AIEE-member Hughes Fellows will take advanced courses toward master's degrees at the University of Southern California, the University of California at Los Angeles, California Institute of Technology, and University of Arizona.

They worked full-time during the summer months and will work part-time during the regular academic year in jobs closely related to their studies. They are considered professional engineers or scientists and are members of the Hughes technical staff. The fellowship employees are paid salaries based on ability and pre-

vious experience and their tuition, fees, and cost of books are borne by the company.

Fellowship winners and their undergraduate schools are: C. L. Ackerman, U. of Tennessee; C. V. Agnew, Pennsylvania State U.; R. L. Barnoski, U. of Missouri; J. J. Battistelli, U. of Connecticut; J. K. Berger, U. of California at Los Angeles; T. S. Bettwy, Villanova U.; S. H. Bickel, Drexel Institute of Technology; J. S. Bolen, Pennsylvania State U.; T. R. Boughnou, Georgia Institute of Technology; B. E. Capron, U. of Nevada; J. M. Colebank, U. of California; T. J. DeLange, U. of Utah; J. C. Donovan, Marquette U.; H. E. Fiala, North Dakota State College; Wendell Ford, Oklahoma State U.; S. R. Fox, Columbia U.; R. D. Fusinati, U. of Illinois; G. F. Garlick, South Dakota School of Mines and Technology; J. C. Hill, U. of Louisville; M. H. Hippensteel, Rose Polytechnic College; R. B. Hogue, U. of Illinois; D. R. Howard, Purdue U.; K. A. Huelsman, U. of Louisville; P. A. Jensen, U. of Idaho; R. K. Kadoguchi, Illinois Institute of Technology; C. E. Kastenholz, Marquette U.; E. R. Kjerulff, S.D. School of Mines and Technology; J. G. Leetmaa, Case Institute; J. L. McFarland, Texas Technological College; L. J. Martire, Rensselaer Polytechnic Institute; N. G. Nelson, Polytechnic Institute of Brooklyn; J. A. Nicoletti, U. of Santa Clara; D. E. Niemoeller, Purdue U.; J. B. Payne III, Virginia Military Institute; R. J. Pettitt, U. of California; A. C. Phillips, North Carolina State; D. A. Pierre, U. of Illinois, R. E. Pike, U. of New Hampshire; R. L. Porter, Iowa State College; C. J. Raymo, U. of Notre Dame; N. C. Rigby, U. of Utah; Lee Rosenthal, Polytechnic Institute of Brooklyn; D. E. Schrader, U. of Illinois; T. C. Stockdale, Purdue U.; D. P. Sullivan, U. of Notre Dame; E. W. Weber, Case Institute; D. O. Wennerstrom, Oregon State College; C. W. Winslow, U. of Oklahoma; Torao Yoshida, U. of Wyoming; and A. L. Zussman, City College of New York.

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Atom-Smasher To Be Constructed at Yale

A new electron linear accelerator with high-energy beam power will be constructed at Yale University, New Haven, Conn.

Cost of building and installation of the new atom-smasher will be in excess of $1 million and will be financed by the U.S. Atomic Energy Commission (AEC). Construction of the machine will start immediately and is expected to be completed in two years.

The announcement is the second major report on linear accelerators at Yale in recent months. Last April, Yale physicists put into operation a powerful heavy ion linear accelerator also with AEC financing.

Linear accelerators are so named because they accelerate atomic particles, such as heavy ions or electrons, to high speeds in a straight line. The new electron accelerator will replace Yale's present 6.5 million-volt, lower current electron machine built and designed by Yale scientists under AEC support 6 years ago.

Housing for the two Yale atom smashers—the electron and heavy ion accelerators—is provided in the Accelerator Laboratory on Pierson–Sage Square.

The new electron linear accelerator will operate normally at 40 million volts, at nearly one ampere of current. Yale scientists said, however, that at smaller currents the beam-energy will exceed 60 million volts.

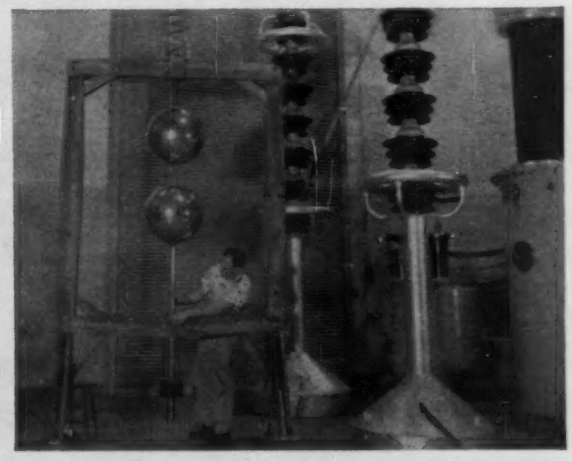
England has in an advanced state of construction a machine of somewhat similar design at its Harwell atomic center, and the USSR has reported that Soviet scientists are constructing a machine of comparable energy, according to the Yale scientists.

While a peak of 60 million volts is not an amazing voltage when compared to other existing machines of a different type, Professor W. W. Watson, chairman of Yale's physics department, and H. L. Schultz, who is project director of the new installation, stressed the fact that the Yale accelerator will be of extremely high intensity.

The new accelerator will operate as follows: accelerated electrons, shot at high speeds, will be stopped by a target material and forced to give off high X-ray radiation. This radiation, in turn, releases neutrons from another target material. Once the large number of all-important neutrons are available, they will be used to bombard various atomic nuclei in advanced studies of nuclear structure.

Yale's present electron accelerator has a water-cooled target which is a small gold block about the size of a large lump of sugar. "The new target," said Professor Schultz, "may be a closed-circuit of rapidly

High-Voltage Laboratory Dedicated to F. O. McMillan



ON APRIL 26, 1958, the High-Voltage Laboratory, located in Dearborn Hall, Oregon State College, was dedicated to F. O. McMillan, formerly head of the department of electrical engineering, who served as president of AIEE, 1951-52. Above, *left:* At the dedication ceremonies were: (*left to right*) F. R. McMillan, son of F. O. McMillan; E. C. Starr, chief engineer, Bonneville Power Administration and a director of AIEE, who presented the historical background of the development of the Laboratory; and L. N. Stone, head of the electrical engineering department and in charge of high-voltage research. *Above, right:* View of the Laboratory showing the 50-cm sphere gap in foreground and the 350,000-volt transformer at the extreme right. The Laboratory was completed in 1952 and has been used for corona and radio noise studies, as well as for educational work in high voltage. Prof. McMillan, who died in 1956, pioneered in the development of the Laboratory.

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moving mercury in order to withstand the great heat given off when the electron beam strikes the target."

The new Yale–AEC machine will have an accelerating chamber measuring 40 feet long, as compared to the 10-foot length of the present machine. Some of the highest power radar transmitting tubes in existence will be used in the device.

At present, the "hot chamber" where the 6.5 million-volt accelerator operates is pointed into a hill so that the target where the intense radiation is produced is well shielded. The accelerator room is encased in 6-foot thick concrete walls, entered by means of a unique 30-ton 6-foot door so set in its frame that it can be moved easily by hand.

The new accelerator will produce such great intensity of radiation, that the "hot chamber" will probably have to be expanded even deeper into the hill of Pierson–Sage Square where Yale's nuclear physics laboratories are situated. "The whole installation," said Professor Schultz, "will be operated by remote control and all personnel will be very well protected against radiation hazards." In fact, it will be safe for persons to walk across the brow of the hill immediately over the target area.

Closely associated with Professor Schultz in the installation and operation of the new atom-splitter are C. K. Bockelman and J. E. Draper, assistant professors of physics at Yale. These three scientists are working together as a team on all phases of the specifications, construction, and research aspects of the installation.

New School of Engineering Building for Cooper Union

I. S. Olds, chairman of the trustees of The Cooper Union, New York, N. Y., has announced that the firm of Voorhees Walker Smith and Smith, architects, has been retained to design a new School of Engineering building for Cooper Union.

Planning for the new structure, estimated to cost $4 million, is in charge of a recently reconstituted Cooper Union Building Committee, headed by Trustee C. F. Craig.

"Construction of the engineering building," said Mr. Olds, "constitutes the first phase of an improvement program on which Cooper Union, a tuition-free private college, has embarked for its centennial to be observed during 1959-60. Contributions and pledges for that program now total nearly $5.15 million but we must obtain an additional $2.5 million to reach our Centennial Development Fund goal. It is the minimum which must be attained for the continued development of Cooper Union's educational services."

Voorhees Walker Smith and Smith is now designing a number of educational building projects, including the Fordham Center at Lincoln Square, the Princeton Engineering Quadrangle, an engineering building at Harvard, and a science center at Rensselaer Polytechnic Institute.

Appointments in Rochester's New College of Engineering

Two major appointments in the new College of Engineering of the University of Rochester have been announced by Dr. C. W. de Kiewiet, president of the University.

Dr. L. D. Conta, professor of mechanical engineering and chairman of the Division of Engineering since 1950, has been named acting dean of the College.

Dr. D. W. Healy, Jr., a member of the engineering faculty at Syracuse University since 1951, has been appointed professor of electrical engineering and chairman of the new department of electrical engineering. Both appointments were effective as of September 1, when the former Division of Engineering became the College of Engineering.

IIT Reports on Engineering Graduates' Salaries

Average starting salaries for 1958 engineering graduates are matching last year's all-time high. Average starting pay for January and June engineering graduates at Illinois Institute of Technology (IIT), Chicago, Ill., was $470 a month—the same as last year, according to E. C. Kubicek, director of placement.

The 1957 electronics boom brought electrical engineering starting salaries to $515 a month last year, he said. This year's electrical engineering average was $470 a month.

"However, mechanical engineers, who are more basic in industrial application, commanded an average monthly salary of $483 compared to last year's average of $465," Mr. Kubicek added.

The over-all average, he pointed out, also included starting salaries for chemical, civil, fire protection and safety, food, industrial, and metallurgical engineering, and mechanics graduates.

Figures, based on a 40-hour work week, do not include starting salaries of graduates whose work experience prior to graduation exceeds one year.

Neither are statistics included for graduates who did the major portion of their undergraduate work in the IIT evening division while regularly employed, ROTC students who went immediately into the Armed Forces, or those continuing for graduate study.

"In spite of talk of recession, depression, and layoffs, there has been no material change in industry's demand for qualified engineers holding a bachelor's degree," he said.

"Companies are becoming more and more selective," he added. "They want engineers who suit their needs—whether or not the graduates are draft exempt or in the top quarter of their class."

The market for engineers still is greater than the number of graduates, Mr. Kubicek added. He quoted a 1957 national survey made by industry which showed that a company was successful in recruiting when it secured 52% of the engineering graduates it needed through college recruitment.

"However, college recruiting still remains the most effective way for American industry to secure much-needed engineering personnel," Mr. Kubicek said.

Interviews for 579 companies and Government agencies were scheduled by IIT in 1958 and approximately 1,600 personal interviews were arranged between company representatives and graduates. Almost 300 companies already have confirmed recruiting dates for the coming year, Mr. Kubicek concluded.

American Nuclear Society Annual Graduate Student Award

The American Nuclear Society has announced the establishment of an annual graduate student award in memory of Dr. Mark M. Mills, former associate director of the Livermore Laboratory of the University of California Radiation Laboratory.

Dr. Mills was killed in a helicopter accident April 7, 1958, at the Eniwetok Proving Grounds in the Pacific. A theoretical physicist and an expert in jet propulsion and atomic energy, Dr. Mills was an expert consultant to U.S. Army Ordnance, and a member of the Reactor Safeguard Committee of the Atomic Energy Committee and of the Scientific Advisory Board, U.S. Air Force.

Dr. Mills taught physics at the California Institute of Technology, lectured in jet propulsion and had worked in atomic energy research at North American Aviation, Inc., in Los Angeles, Calif.

The president of the American Nuclear Society, Dr. Chauncey Starr, vice-president of North American Aviation and general manager of its Atomics International Division, said that "the intent of the Mark Mills award is to recognize the outstanding graduate student working in the nuclear sciences."

The award is the first of its kind to be established by the organization.

Nuclear Training "Package" for Colleges and Universities

More than 50 colleges and universities have requested proposals from Nuclear-Chicago Corporation for a nuclear training "package." This package, shown for the first time at the AtomFair in Chicago, Ill., during March 1958, consists of a natural uranium, water moderated subcritical training reactor, a complete laboratory of nuclear detection and measuring instruments, and a manual of nuclear experiments.

Ranging from the largest technical in-

stitutions to small liberal arts colleges, these 50 schools have expressed a willingness to start a new course or enlarge existing facilities to teach nuclear science and engineering. The Nuclear-Chicago package is designed to help these schools. It also fits into the categories of equipment which the Atomic Energy Commission (AEC) will subsidize under their current educational assistance program. The majority of the schools have submitted requests to the AEC for financial assistance. Many of them met the necessary requirements and have already received funds.

An initial run of 10 reactors is under way at Nuclear-Chicago for installation at the schools this Fall. Complete cost of the package including reactor and instruments is approximately $33,000.

Scholarship Honors Dean Ovid W. Eshbach

A new undergraduate scholarship, honoring the first dean of the Northwestern University Technological Institute, is being awarded for the first time this fall, according to Dean H. B. Gotaas.

The new scholarship, named in memory of Dean Ovid W. Eshbach (F '37), who died last March 4, is being made possible by contributions to the Eshbach Memorial Fund by his associates, students, and alumni of the Technological Institute.

He served as dean from 1939 to 1953 and continued to be active in teaching engineering until his death. The awards will be made on the basis of need, scholarship, and indicated leadership ability in the engineering profession.

Brooklyn Polytechnic Murals Introduce Novel Art Technique

Flanking the main entrance of the new Brooklyn Polytechnic Institute building adjoining the Civic Center in Brooklyn, N.Y., are two large decorative panels that symbolize Polytechnic's work in the fields of science and engineering. They represent a new technique in mural design and execution, based on the passage of light through multiple colors and layers of a modern technological material, Plexiglas acrylic plastic.

The panels are the work of the noted muralist Abraham Joel Tobias, who created them by fitting together thousands of pieces of the acrylic plastic, cut with fine precision to myriad shapes. Approximately 3,500 pieces of Plexiglas, in 58 colors and shades, were used. Each mural is 10 feet tall and 3 feet wide. They were executed by Mr. Tobias at the plastics fabrication laboratory of Rohm & Haas Company, manufacturer of Plexiglas, in Bristol, Pa., with the assistance of the company's fabrication staff.

Each mural is constructed from a 3- by 10-foot transparent acrylic base sheet, ¼ inch thick, overlayed with transparent colored pieces cut to the curves and sharp angles of the designs. The overlay pieces are edge-cemented together to form the intricate pattern involved. Multiple layers—as many as six layers in some sections of the panels—are built up to achieve a 3-dimensional appearance and to obtain subtle variations in color.

The panels are framed in aluminum and covered on each side by a transparent acrylic shield. The shields are sealed to the edges of the frames, to protect the murals themselves from dirt and to make maintenance a matter of simply wiping the transparent covers. Duplicate designs were built up on each side of the base sheets, with the result that the murals function as both interior and exterior architectural art.

The relative color values of the murals remain constant whether seen under transmitted light or reflected light. During the day, outside light passes through the translucent panels, making them glow when viewed from the interior of the building. At night, lobby lighting passes through the panels to the darkness outside, making them glow when viewed from the street.

According to Mr. Tobias, "The murals open up new horizons in the field of architectural treatment. Because of the strength and light weight of the Plexiglas pieces and the fact that they can be edge-cemented to each other, the traditional stained glass technique has been freed from the need for using lead around small individual sections, and the use of cross supports, thus providing greater scope of design for the artist and architect. In multiple units, the Plexiglas panels could cover an extensive area. The panels represent the use of new materials, developed by our advances in science and technology, to create an effect which is in harmony with the building concepts of our age. Science is not only the theme but also the source of the materials for this contemporary work of art."

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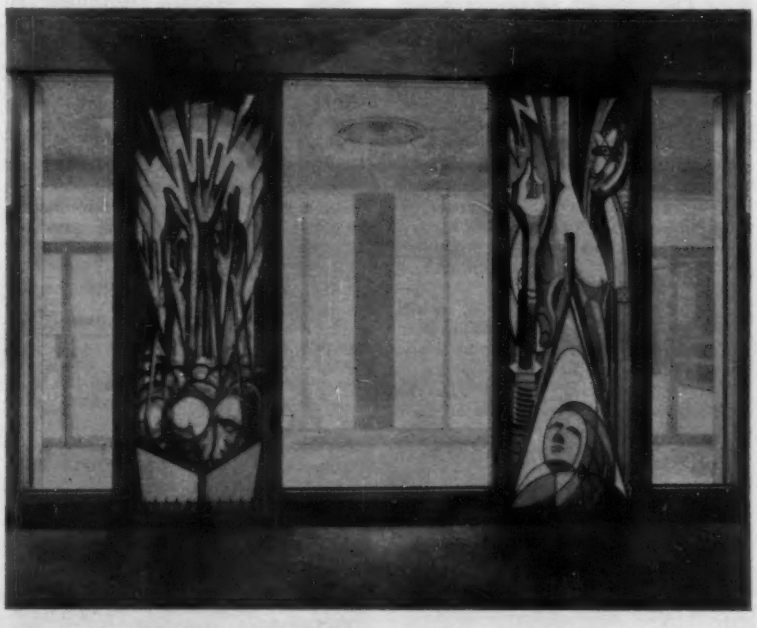
Off Key Symphony?

How far out of tune should violinists play in a symphony orchestra?

This paradoxical question will be the kind of problem to be studied scientifically at Massachusetts Institute of Technology (MIT) under an $80,000 grant made by the National Association of Music Merchants (NAMM) for research in musical acoustics. Although there have been musicians for thousands of years, relatively little is known about what music really is, according to Dr. Melville Clark, Jr., who will be chairman of the committee in charge of the research.

"If all of the violinists in an orchestra played the same note in exactly the same



TWO 10-FOOT MURALS, symbolizing "Science" and "Engineering," fabricated from Plexiglas, provide a unique architectural treatment of the entrance to the new Brooklyn Polytechnic Institute building. Designed and executed by the noted artist and muralist Abraham Joel Tobias at the plastics fabrication laboratory of the Rohm & Haas Company, these works of art represent the evolution of a new mural technique. The artist constructs the mural from individual precut pieces of pigmented acrylic plastic, cemented into one or several layers, to produce three-dimensional effects and extraordinary range of subtle color gradations.

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way, the sound would be that of a single violin amplified," explained Dr. Clark. "Of course they must play very close together in order to produce good music, but they play just far enough apart—in pitch and timing—to achieve a richness, an aliveness, which they would not have if they were playing precisely alike.

"This minute difference, which no musician could measure by ear, makes a great deal of difference in the sound of instruments. In the laboratory, we hope to be able to make exact measurements of such elements." The makers of musical instruments will be enabled to improve them and perhaps even to invent new kinds of instruments. It may prove to be of help to musicians and to the designers of concert halls.

MIT was notified of the grant by Paul Murphy, NAMM president. The board of directors authorized the grant at the last meeting of NAMM, which has a membership of retail merchants throughout the United States.

The research will be supervised by a committee consisting of Dr. Clark, assistant professor of nuclear engineering; Dr. M. W. P. Strandberg, associate professor of physics; and Dr. W. M. Siebert, assistant professor of electrical engineering. All three have an avocational interest in music. Professor Clark was an organist and once played the trombone. Professor Siebert plays the clarinet and saxophone. Professor Strandberg played the violin as a boy, but now limits his fireside performances to the recorder.

Dr. Clark explained that interest in music research at MIT is only one aspect of a very broad interest in music among both faculty and students. Resident musicians on the faculty, seven courses offered in music, an extensive music library, and an active choral society, a symphony orchestra, and a band are additional reasons for the choice.

Not even the best musicians in the world, or the most appreciative listeners, can analyze music in the way that is possible with electronic instruments, according to Dr. Strandberg. Anyone can tell the difference between the sound of an oboe and that of a violin; yet just what this difference is has not been determined scientifically.

The research will be divided into two phases: in the analytical phase, elements of a musical tone will be identified and measured; in a synthesis phase, the significance of these elements is to be assessed by determining how much an element can be altered before the alteration is heard.

Is a musical instrument creating a tone identified by the first part of the tone during which it is increasing, the middle part during which it is constant, or by the last part during which it is decreasing? How significant are the changes of the tone during each of these three parts?

Is the matter of detuning a tone related to the distinction between a solo tone and a choral tone—that tone produced by a large number of like instruments sounding the same note? Perhaps a choral tone is just the superposition of a large number of very slightly mistuned notes. Perhaps the characteristic feature of a choral tone is the slightly different times at which the note is struck. Those are some of the things it is hoped will be learned.

ERI Becomes "University of Michigan Research Institute"

Changes in the name and functions of the Engineering Research Institute (ERI) at The University of Michigan have been approved by the Regents.

The new name will be "University of Michigan Research Institute." Its functions have been broadened to include all areas of University contract research programs. ERI research had been concentrated largely in engineering and the physical sciences.

The changes were recommended to the Regents after more than two years of consideration and discussion by faculty committees and administrative officials.

Other changes approved by the Regents were:

1. Substitution of an executive committee, thus permitting more direct and effective participation by representatives of various faculties, for the former policy council.
2. A majority of the policy-making group (the executive committee) no longer will have to come from the College of Engineering as was the case with the policy council.
3. The director of the Institute now will report to the vice-president and dean of faculties rather than to the dean of the College of Engineering.
4. The Willow Run Laboratories are recognized as a separate research unit with a director and executive committee. These Laboratories are to confine research activities to the fields of engineering and physical sciences, as deemed appropriate and in the best interest of the University.

In separate actions, the Regents approved the appointment of R. E. Burroughs, acting director of ERI since March 1, 1958, as director of The University of Michigan Research Institute and of J. A. Boyd as director of the Willow Run Laboratories. Both appointments were effective July 1, 1958. Executive committees for both units also were approved.

Howard Hughes Fellowships Awarded

Six outstanding postgraduate university students have been awarded Howard Hughes Fellowships in Science and Engineering—established for the continued education of promising young research engineers, mathematicians, and physicists—for 1958-59, Dr. A. V. Haeff, vice-president, Hughes Aircraft Company, has announced.

Seven other renewals of existing fellowships were also announced by Dr. Haeff in addition to two special awards. All 15 fellowships materially assist successful candidates in obtaining doctoral degrees in various scientific specialties.

New fellowships for 1958-59 were awarded to W. P. Brown, Viktor Evtuhov, L. S. Pilcher, H. E. Rauch, J. H. Renken, and G. W. Simon.

Renewals went to J. P. Andelin, Jr., D. C. Forster, Nick George, Jr., P. H. Levine, J. J. Merrill, J. E. Olivares, Jr., and P. M. Platzman.

R. G. Hering and D. M. Tompkins, Jr., have been awarded special doctoral fellowships.

Each of the new and renewed fellows will receive a grant from a fund established by industrialist-aviator Howard Hughes to cover tuition, research, and other expenses while doing postgraduate work, and will also receive a salary from Hughes Aircraft during certain intervals of the year while working in its Culver City research laboratories.

Mr. Brown, Mr. Evtuhov, Mr. Pilcher, Mr. Renken, and Mr. Simon will begin their doctoral studies at California Institute of Technology in Pasadena, Calif. Mr. Andelin, Mr. Forster, Mr. George, Mr. Levine, Mr. Merrill, and Mr. Platzman will continue their work at Cal Tech. Mr. Rauch will attend Stanford; Mr. Olivares, University of California at Berkeley; and Mr. Hering and Mr. Tompkins, Purdue University in Indiana.

Dr. Haeff, who is chairman of the fellowship committee and head of Hughes' research and development laboratories, said the fellowship program, combining advanced theoretical training with industrial tutorial training, was developed by Hughes in 1948 in recognition of the increasing need for creative research men who can apply both scientific and industrial techniques in the solution of increasing complex technological problems.

Increasing Interest Shown in Atomic Energy

L. L. Strauss, chairman of the Atomic Energy Commission (AEC), has reported that United States students and teachers are displaying increasing interest in all phases of atomic energy. A substantial growth in interest is indicated by the larger numbers of requests for educational material coming to the AEC.

Currently, requests for materials are coming in at a rate nearly seven times that of 1954. In each of the last three years, the rate has nearly doubled that of the previous year.

During the first four months of 1958, the AEC received 15,120 requests for materials, an indication that the 1957 total of 18,815 requests will be greatly exceeded this year. Totals for earlier years were 10,407 in 1956; 6,419 in 1955; and 5,600 in 1954.

The increases are believed to be note-

worthy in relation to the effort being made on many fronts to strengthen and enlarge science programs in the nation's schools.

Requests cover all areas of atomic energy and come from students of all ages and their teachers. They seek information on the atom in agriculture, food irradiation, medical research and development, the power program, basic research, industrial uses of radioisotopes, uranium prospecting, how to construct a cyclotron, how to build a Geiger counter, radiation effects, the "Atoms for Peace" program, and many allied subjects. There has been a significantly large increase in requests for information on careers in atomic energy.

Requests are not confined to the United States. Students from nearly every foreign country have asked for and received information on various peacetime aspects of atomic energy.

Many of the requests can be filled by one of several standardized kits of materials, assembled by the AEC to aid elementary, high school, or college students, teachers, and vocational guidance counselors. Other inquiries are met by copies of reports or speeches originally prepared for other purposes. A considerable number pose specialized questions that can be answered only by a personal letter from one of the AEC's staff.

Every request receives an answer. The AEC recognizes that behind each inquiry lies a curious mind that may someday make a significant contribution to the world's scientific and technological progress.

New Facilities for Electrical Engineering Education

Rapid progress is being made on the construction of a new classroom and laboratory building for the electrical engineering department of the Missouri School of Mines and Metallurgy at Rolla, Mo.

The 3-story building is of reinforced concrete column and beam construction. The long exterior north and south elevations of the building are of panel wall construction with aluminum sash. At the east and west ends, the building is terminated with brick masses containing stairways.

The building project includes, on the ground floor, electrical machinery laboratories, two computation rooms, photographic laboratory, network analyzer room, work shop, instrument room, and several research rooms. The middle floor includes 8 large classrooms, conference room, 10 offices for staff members, and main department office. The upper floor includes eight electronic type laboratories such as for electronic circuits, electrical measurements, radiation and antennas, digital and analog computers, advanced networks. This floor also includes three large classrooms and six office or research rooms as well as instrument room and repair shop.

The building program was developed under the guidance of Dr. Elmer Ellis, president of the University of Missouri; Dean C. L. Wilson of the Missouri School of Mines and Metallurgy; and Prof. I. H. Lovett, chairman of electrical engineering department, as well as staff members of the department. The building has been designed by P. John Hoener and Associates, architects, and John D. Falvey, mechanical engineer of St. Louis, Mo. Buckley Construction Company of St. Louis is the general contractor.

It is expected that the building will be completed in the Summer of 1959 so that present equipment may be moved to the laboratories in time for the Fall semester starting in September. The facilities of this building will be adequate to provide necessary space for estimated enrollments during the next 10 years. While much of the present equipment of the department will be used in the new building, it is expected that funds will be available in the appropriation for a considerable amount of new equipment which will be needed on account of increased enrollment.

Senior Postdoctoral and Science Faculty Fellowships

Applications will be accepted through October 15, 1958, by the National Science Foundation (NSF) for both the senior postdoctoral and science faculty fellowships, A. T. Waterman, NSF director, has announced. Henceforth, these fellowships will be awarded annually in December rather than biannually as awarded in previous years. Awards will be made in the mathematical, physical, and engineering sciences; medical and biological sciences including anthropology and psychology (excluding clinical psychology); and in selected social science fields. Included as well are interdisciplinary fields which overlap two or more scientific disciplines. Names of successful fellowship candidates will be announced on December 5, 1958.

To be eligible for senior postdoctoral fellowships, candidates must be citizens of the United States with special aptitude for advanced training and must have held the doctoral degree for at least five years or have equivalent education and experience. Senior postdoctoral fellows will be selected on the basis of ability as evidenced by letters of recommendation and other evidence of attainment. Candidates' qualifications will be evaluated by carefully chosen panels of scientists under arrangements made by the National Academy of Sciences. Final selection of approximately 100 fellows will be made by the NSF and announced on December 5, 1958.

The science faculty fellowships are directed toward college teachers of science who wish to improve their competence as teachers. These fellowships are open to application by any citizen of the United States who holds a baccalaureate degree or its equivalent, has demonstrated ability and special aptitude for science teaching and advanced training, has taught at the collegiate level as a full-time faculty member for not less than 3 years and intends to continue teaching. Selection will be based on letters of recommendation, academic records, and other appropriate evidences of professional attainment and competence. Applicant's qualifications will be evaluated by persons especially competent to make judgments as to the demonstrated and potential ability of the applicant as a teacher of science under arrangements made by the Association of American Colleges. Final selection of approximately 300 fellows will be made by the NSF and announced on December 5, 1958.

Annual stipends to a maximum of

P. John Hoener and Associates, Architects

ARCHITECTURAL SKETCH of the new electrical engineering building under construction at the Missouri School of Mines and Metallurgy.

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$12,000—adjusted to match as closely as feasible the regular salaries of the recipients—will be awarded under both these programs. Fellows may engage in study or research at any accredited nonprofit institution of higher learning in the United States or any similar institution abroad approved by the NSF. A limited allowance to aid in defraying the cost of travel for a fellow and his dependents will also be available.

Application materials may be obtained from the Division of Scientific Personnel and Education. National Science Foundation, Washington 25, D.C. Completed materials must be received not later than October 15, 1958.

University of Texas To Analyze Data for TASO

The Television Allocations Study Organization (TASO) has completed arrangements with the University of Texas, Austin, Tex., whereby the University, through its Bureau of Engineering Research, will undertake the analysis of the uhf and vhf propagation data which have been taken by TASO and by those working in collaboration with TASO. The University of Texas has a deservedly high reputation for its research in the field of wave propagation and has a staff which has contributed greatly to the present knowledge of this phase of the art of electrical communications.

Dr. A. H. LaGrone, associate professor of electrical engineering, will be in direct charge of the project at the University of Texas while Dr. A. W. Straiton, director of the Electrical Engineering Research Laboratory, will have general supervision of the work.

The field strength measurements which are to be analyzed, and upon which new propagation curves applicable within the service range of television transmitters will be based, have been taken in many areas of the country by many groups. These include the Association of Maximum Service Telecasters, CBS Television, Westinghouse Broadcasting Company, the FCC, and individual uhf and vhf stations and their engineering consultants. The analysis of the data is the responsibility of TASO Panel 5—Analysis and Theory. The work at the University of Texas represents one part of the activities of this TASO Panel.

Funds for financing the project at Texas have been contributed by the television industry. The TASO Board of Directors recently undertook to raise a special fund of $75,000 to $100,000 to finance this and other technical tasks needed to complete the work of TASO. To date, over $55,000 has been contributed to TASO for this purpose by the industry.

Cornell Students To Study Vacuum Metallurgy at First-Hand

Students studying metallurgical engineering at Cornell University and other engineering students electing the nuclear engineering option will learn the latest techniques in vacuum melting and refining with the help of a new Stokes induction-heated vacuum melting and refining furnace which has recently been delivered and will be put in operation immediately.

The unit is a standard Stokes Model *437* "package" furnace, complete with its own vacuum pumping system, 30-kw induction power supply, and a crucible capable of melting and pouring 17 pounds of metal. It will form an integral part of Cornell's engineering laboratory equipment and will be one of the first such units to be installed at an American university for the everyday use of undergraduate students—as distinct from units used for contract research. It marks the growing recognition by educational institutions of the importance of vacuum processing as a standard industrial tool.

The furnace was purchased with a grant from the Atomic Energy Commission.

Two Universities Install Burroughs *205* Digital Computers

Two Rocky Mountain Universities will install Burroughs *205* electronic computing systems, to strengthen automation training and research in the nation's schools.

The general-purpose digital computers have been ordered by the University of Utah, in Salt Lake City, and the University of Denver, Colo.

Manufactured by the ElectroData Division of Burroughs Corporation, the high-speed data processing equipment will be used by schools for laboratory instruction, statistical analysis, and research—ranging from air pollution studies to high-frequency radio design.

Special financial arrangements are made by Burroughs Corporation on university contracts to facilitate computer purchases.

Educational institutions currently employing the *205* include the California Institute of Technology, University of Dayton, Purdue University, Stanford Research Institute, and the University of Chicago.

Burroughs desk-sized *E101* electronic computers are also installed at the Massachusetts Institute of Technology, Princeton, Harvard, Georgetown, and New York Universities, and the Universities of Pennsylvania, Detroit, Cincinnati, and Missouri.

Cincinnati Section Holds Student Paper Competition

This year, the Cincinnati Section of the Institute held its 30th Annual Student Prize Paper Competition for members of the senior class in electrical engineering at the University of Cincinnati. Started in 1929 by the late Prof. Alexander M. Wilson to provide an opportunity for outstanding members of the University of Cincinnati senior class in electrical engineering to present their thesis projects, this annual competition has developed into a tradition with the Cincinnati Section.

Four papers were presented. First prize was awarded to R. C. Scherer and Stanley Silverman for their joint paper on "Unbalanced Operation of Induction Motors." Second prize was awarded to R. H. Raible and J. T. Ruther for their joint paper on

AT THE 30th Annual Student Prize Paper Competition held by the AIEE Cincinnati Section for members of the Student Branch of the University of Cincinnati were (*left to right*) Prof. A. C. Herweh, head of the department of electrical engineering; and student contestants: Stanley Silverman, J. T. Ruther, G. F. Metz, T. R. Frecka, R. H. Raible, R. C. Scherer, J. R. Dietz.

"A Line Tracer." Honorable mention was given to G. F. Metz for his paper entitled "A Frequency Divider," and for the joint paper by J. R. Dietz and T. R. Frecka entitled "Electronic Determination of Fourier Coefficients."

ASEE Officer Discusses Need for Engineering Teachers

A warning that at least 1,000 new engineering teachers will be needed each year until the rising tide of students reaches its climax was offered recently by C. L. Eckel, dean of the College of Engineering at the University of Colorado. The engineering educator delivered the keynote address during the Rocky Mountain Section meeting of the American Society for Engineering Education (ASEE), held at the Colorado School of Mines, Golden. Dean Eckel is vice-president for the western division of ASEE.

"Our basic problem will probably lie in salaries," he said. "A 40% increase in salaries in the near future would do much to offset the business opportunities offered to present graduates. Our current salaries cannot attract the young engineers who would excel in the teaching profession. This profession must upgrade itself, but the current academic climate is not a stimulating one for professional development. Far too many engineering fellowships and other opportunities for advanced study go begging today because young engineering teachers cannot afford the time or money for such study.

"The teacher can attend night courses and work during all his off hours. But studies have indicated the best advanced teacher is the one who takes a concentrated graduate study program, not the piecemeal night or summer program."

Teacher recruitment was the topic discussed during the Young Engineering Teacher session. Some members offered small teaching posts as a possible solution to retaining potential teachers. By allowing bright engineering students to handle classes during their senior year, a recognition of the importance of teaching will be gained. ASEE members agreed that industry opportunities provided the major opposition to bright students.

More than 125 engineering educators attended the two-day meeting. Also present were engineers from various industrial firms.

During the business session, new officers for the Rocky Mountain Section were elected. They were Prof. C. H. Milligan, Utah State, chairman; Col. Archie Higdon, Air Force Academy, vice-chairman; Prof. A. G. Loveless, Utah State, secretary; Capt. F. R. Bonanno, Air Force Academy, subchairman for the Young Engineering Teachers Division; Prof. W O. Birk, Colorado University, representative on the ASEE English Committee; Prof. G. W. Lemaire, Colorado School of Mines, chairman of the Committee on Industrial Relations; Prof. Davis Bartholomew, national council representative; and Prof. W. H. Parks, Denver University, alternate national council representative.

Lowell Tech Library Receives Engineering Books

The Alumni Memorial Library at Lowell Technological Institute has received a collection of books on electrical engineering, steam engineering, and mechanism owned by the late Hugo W. H. Wellington (AM '38), vice-president and assistant to the president of Boston Edison Company. Librarian J. V. Kopycinski announced that at present the collection totals 114 items, with more to come later.

Presentation was made by the Wellington family through R. K. Wellington. Dr. G. R. Griffin, chairman of the Division of Chemistry at Lowell Tech, was instrumental in bringing this collection to the Library.

The late Mr. Wellington, through long service on national and regional technical committees, had been recognized as one of the best-informed utility officials in the country on the subject of electric generating stations.

Westinghouse Educational Foundation Announces Awards

The Westinghouse Educational Foundation has announced that it will award $800,000 this year to colleges and universities and to individual scholars. Dr. J. A. Hutcheson, chairman of the Foundation's board of trustees and vice-president in charge of engineering for Westinghouse Electric Corporation which solely supports the Foundation, said the $800,000 is a near-record budget. Because of this financial help, he said: 146 students are going to college or graduate school this year on scholarships and fellowships, 5 college professors hold full-time teaching posts, 10 colleges and universities are conducting special study programs, and 55 institutions are receiving engineering laboratory equipment or funds to meet operating expenses and building fund goals.

The Westinghouse Educational Foundation was established as an independent educational trust in 1944. The $800,000 budget announced now is not connected with grants and scholarships awarded by Westinghouse Electric Corporation and its divisions, which maintain programs of their own.

"Grants to help finance special programs carried on by colleges and universities cover a broad range of subject," Dr. Hutcheson observed. "For example, the Foundation has paid $45,000 and has budgeted $30,000 more over the next 2 years, to help a New England institution build and equip a nuclear reactor and new laboratory for the training of future scientists urgently needed in this field. The Foundation is among the supporters of a West Coast university that has established a computer center."

Funds allocated to professorships, fellowships, and scholarships and other programs aimed at encouraging or recognizing individual effort will total approximately $355,000 this year. Money directed to colleges and universities in other activities will total about $435,000. Included in this part of the program are grants for special programs, contributions for engineering laboratory equipment, and money allocated for building funds and general operating expenses.

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Rutgers Receives Esso Grant for Research

The receipt of $3,500 from Esso Research and Engineering Company of Linden, N.J., for continuance of its support of basic research in the Rutgers department of electrical engineering was announced by Dr. L. W. Jones, president of the State University.

The award will be used to aid a research program being conducted by A. B. Ward, candidate for a master's degree in electrical engineering. Mr. Ward, a 1957 Georgia Tech graduate, is studying the flow of solid matter, such as sand and clay, as it is carried in a fluid state by air or other gases at high temperature.

L. A. Rosenthal, associate professor of electrical engineering, is adviser to Mr. Ward, who started the project last Fall through a similar grant from Esso Research and Engineering Company.

Westinghouse Engineer Awarded Lamme Scholarship

Westinghouse Electric Corporation has awarded a graduate scholarship for a year of advanced study to an engineer at its Electronics Division at Baltimore, Md., it was announced recently.

Dr. J. A. Hutcheson, vice-president in charge of engineering and chairman of the scholarship committee, said Leo Young has been chosen as the 20th recipient of the Benjamin Garver Lamme graduate scholarship. He will engage in graduate study in electrical engineering at Johns Hopkins University, Baltimore.

The Lamme Graduate Scholarship Fund was established by Westinghouse in honor of the company's former chief engineer. So far, 19 Westinghouse engineers who were considered exceptionally able have been granted the scholarships to continue advanced study on a full-time basis at universities in this country and abroad.

The award includes a stipend of $2,500, payment of full tuition, and a support fund to the institution of $1,000. This year, the total amount of the scholarship will be approximately $4,500.

Receipt of the Lamme Scholarship is informally considered as recognition of being the company's outstanding young

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engineer of the year. Nominees from Westinghouse locations throughout the country are carefully screened for the person possessing the highest degree of creative ability and leadership qualities.

Mr. Young is a native of Vienna, Austria. He was graduated with honors from St. John's College, England, in 1945 with a bachelor of arts degree in mathematics. He received his B.A. in physics, also with honors, from Cambridge two years later. In 1950, he received a master's degree in mathematics and physics from St. John's College. He was conferred a master's degree in electrical engineering from Johns Hopkins in 1956.

Mr. Young is a fellow engineer with the Electronics Division and has been with Westinghouse since 1953. During the past 4 years, he has written 17 technical articles for professional publications.

Purdue Professor Elected President of ASTM

K. B. Woods, head, School of Civil Engineering, and director, Joint Highway Research Project, Purdue University, has been elected president of the American Society for Testing Materials (ASTM).

Prof. Woods began his association with Purdue University in 1939 as assistant professor of highway engineering. In addition to his academic work, he is well known throughout civil engineering circles for his work in engineering research and as a consultant to Canadian and U.S. Government agencies and to railroad and other industrial concerns dealing with the location, design, and construction of air fields, railroads, and highways in Alaska, Canada, and the United States.

New vice-president of ASTM will be A. A. Bates, Portland Cement Association. F. L. LaQue, The International Nickel Co., Inc., will continue as senior vice-president.

Engineering Educator Receives 1958 NSPE Award

N. W. Dougherty, dean emeritus, University of Tennessee, has received the 1958 NSPE Award of the National Society of Professional Engineers (NSPE).

Presented at the annual meeting of the NSPE in St. Louis, Mo., the Award was made to Dean Dougherty ". . . in recognition of his outstanding leadership in his profession as evidenced by his devotion to the advancement of engineering education, his sympathetic encouragement of students of engineering, his zealous promotion of the ideals and principles of his profession, and his humanitarian interest in his fellow men."

Dean Dougherty was a member of the University of Tennessee faculty for 40 years, the last 16 as dean of engineering. He is a past president of the American Society for Engineering Education, has served as chairman of the Tennessee State Board of Architectural and Engineering Examiners, and has served as a member of the Board of Direction and vice-president of the American Society of Civil Engineers.

He has also been chairman of the National Council of State Boards of Engineering Examiners, and a vice-president of the NSPE.

Dean Dougherty is the eighth recipient of the NSPE Award.

Electrical Engineers in Demand at Lehigh University

Electrical engineering majors graduated from Lehigh University in June went through a busy job placement schedule according to E. A. Teal, director of placement and counselling.

The 44 seniors sat for 317 job interviews which produced 127 job offers. The average starting salary for electrical engineers will be a $485, a drop of $3 from a year ago. Graduate students who received master of science degrees will begin work at an average of $556 a month.

Electrical engineers who got their sheepskins in June will receive $11 a month more than the average starting salary for all engineering graduates. Mr. Teal's report indicates $474 as the average starting salary for all engineers compared to $465 a year ago.

Business administration majors will be getting $412 a month compared to $398 in 1957. A drop of $10 from $391 to $381 is reported for graduates of the College of Arts and Science.

Six of Lehigh's electrical engineers turned down job offers in order to continue advanced studies at graduate schools. Two others have military service commitments. Only two are actively seeking employment.

Mr. Teal's report reveals that 14 more companies sent representatives to the Lehigh campus in 1957-58 than a year ago. Personnel men from 294 companies held 4,947 interviews with 505 seniors.

Oak Ridge Traveling Lecture Program

The Oak Ridge Institute of Nuclear Studies (ORINS) has issued a "catalog of talent" to colleges and universities in the southern region, which offers the services of 106 Oak Ridge scientists who will be available to lecture on college campuses on more than 150 topics that span every field of scientific endeavor. They will tailor their talks for either undergraduate consumption, or more technical graduate and faculty gatherings.

This arrangement is made possible through the Oak Ridge Traveling Lecture Program, a joint activity of the Atomic Energy Commission (AEC), Oak Ridge National Laboratory (ORNL), and ORINS. Now in its 11th year, the program enables Oak Ridge scientists to continue their contribution to the scientific life of the South by delivering talks, conducting seminars, participating in colloquia, and otherwise taking part in scientific activities on university campuses.

Of the lecturers, 89 are ORNL staff members; 4 are with the University of Tennessee–AEC Agricultural Research Laboratory in Oak Ridge; 7 are on the ORINS staff; and 6 are with the AEC Oak Ridge Operations Office.

The program is designed to serve colleges of all sizes, without cost to the requesting institution. In the interest of efficiency, substitutions of lecturers and dates must sometimes be made, so colleges are asked to give alternate choices, and to make their requests as far in advance as possible. When several colleges in the same area can consolidate their needs to request the same speaker during the same general period, scheduling is greatly facilitated.

The brochure listing the lecturers and their topics is available from the University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

NYU Announces Plans for New Engineering Building

Plans to construct a $2 million engineering and technology building at New York University's (NYU) Bronx campus have been announced by Dr. C. V. Newsom, president of NYU.

Financed by a gift from the late Frank Jay Gould, the four-story and lower-level structure will stand on the west side of the campus between the Sage Engineering Building and Sedgwick Avenue. The University's Board of Trustees has authorized the design of final plans so that construction can start during the year. Completion is anticipated by the spring or early summer of 1960.

"This is the first step in a long-range physical development program at our University Heights Center," President Newsom said. "The program, which is to include the addition of new residential facilities, will affect both the College of Engineering and the University College of Arts and Science. Expanding our facilities for technological education and research is a major objective."

Mr. Gould gave the money for the engineering building prior to his death in 1956. He was an alumnus and an outstanding benefactor of the University. Among his other gifts were the Gould Student Center at University Heights and a 13-acre estate at Ardsley-on-Hudson, N. Y.

Plans for the building have been based on supplying multipurpose facilities. These include instructional laboratories that also can be used for small lecture classes and general-use seminar rooms equipped for slide and film projection and television.

The building will provide space for the departments of electrical engineering and mathematics. Because of its multipurpose design, however, it could be used by other departments.

As soon as funds can be obtained, Dr. Newsom said, the University also will build an adjacent structure housing two lecture halls that will accommodate 160 and 53 persons. This auditorium building will cost $250,000.

A third building containing additional engineering laboratory and classroom facilities is in the preliminary planning stages, Dr. Newsom also announced. This companion structure will have two wings.

Associated Midwest Universities Formed

Some 26 leading educational and research institutions have formed an inter-university corporation to be known as Associated Midwest Universities.

Announcement of the action was made by Dr. J. H. Jensen, provost, Iowa State College, Ames, Iowa, who is the initial president of the new organization.

It is planned to establish headquarters for Associated Midwest Universities at the Argonne National Laboratory's main site near Lemont, Ill. Argonne is the nation's senior research and development center for peacetime uses of atomic energy.

The Associated Midwest Universities have been incorporated as a not-for-profit corporation under the laws of the State of Illinois. An executive director, whose office will be at the Argonne site, will be selected as the new organization's top administrative officer.

"Argonne welcomes the formation of this new organization to give added impetus to scientific development in the Middle West," said Dr. Norman Hilberry, Argonne director. "It promises to become one of the most active groups of its kind in the United States."

The articles of incorporation list three main purposes for organizing the new corporation:

1. To promote, encourage, and conduct research and education in all branches of science, including but not limited to nuclear science in relation to all other fields of science.

2. To establish means for facilitating the use of the Argonne National Laboratory and other laboratories by duly-qualified personnel and students from the several co-operating institutions and other research and educational institutions.

3. To establish, maintain, and operate laboratories and other facilities as necessary for research and education.

Associated Midwest Universities will be governed by a board of directors made up of eight members. Members of the board would be elected normally for terms of 4 years each, so spaced that the terms of office of two of the members of the board will expire each year. At least five of the eight members of the board must be members of the staffs of the sponsoring institutions.

Under the articles, the initial board will consist of the following persons to serve for the terms indicated: Dr. R. G. Herb, professor of physics, University of Wisconsin, term expires June 30, 1962; Dr. Frank Hovorka, head of chemistry department, Western Reserve University, term expires June 30, 1962; Dr. R. S. Shankland, head of the physics department, Case Institute of Technology, term expires June 30, 1961; Dr. W. L. Everitt, professor of electrical engineering and dean, college of engineering, University of Illinois, term expires June 30, 1961; Dr. J. Z. Bowers, dean of medical school, University of Wisconsin, term expires June 30, 1960; Dr. L. L. Quill, head of chemistry department, Michigan State University, term expires June 30, 1960; Dr. N. S. Gingrich, head of physics department, University of Missouri, term expires June 30, 1959; Dr. J. H. Jensen, provost, Iowa State College, term expires June 30, 1959.

Officers of Associated Midwest Universities include Dr. Jensen as president; Dr. L. L. Quill of Michigan State as vice-president; Dr. J. C. Boyce of Illinois Institute of Technology as secretary and acting treasurer. An executive director will be elected by the association's board and will devote full-time effort to the association.

Dr. Schelkunoff Joins Columbia University Faculty

The appointment of Dr. S. A. Schelkunoff (F '51) as adjunct professor of electrical engineering has been announced by J. R. Dunning, dean of the School of Engineering at Columbia University.

Dr. Schelkunoff, who begins his duties at Columbia this Fall, is assistant director of mathematical research at the Bell Telephone Laboratories, Inc., Murray Hill, N.J.

He was born in Samara, Russia, January 27, 1897, and became a naturalized citizen of the United States in 1928. He received his bachelor of arts and master of arts degrees from the State College of Washington, Pullman, Wash., and his Ph.D. in mathematics from Columbia University in 1928.

Dr. Schelkunoff is widely known for his contributions to the electromagnetic theory and is the author of several books on that subject and on antennas and applied mathematics.

He served as a consultant for the U.S. Air Force and the U.S. Navy during World War II, is a fellow of the Institute of Radio Engineers and won the Liebman Prize in 1942. He was awarded the Ballantine Medal of the Franklin Institute in 1949.

New Teaching Reactor for Iowa State College

A special reactor for teaching purposes in the area of nuclear engineering is expected to be operating at Iowa State College before the end of the academic year.

A grant of $150,000 from the U.S. Atomic Energy Commission (AEC) will

Electrical Engineering Education

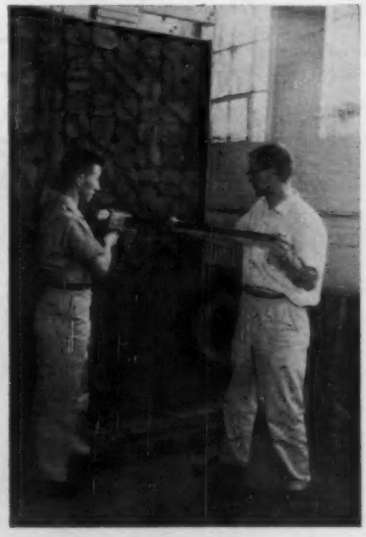
furnish most of the funds necessary for the purchase of the reactor. Bids are to be taken on the project shortly, and actual construction is expected to start some time in the Fall in the Chemical Engineering West Building.

The new facility will provide opportunities for training in the principles of reactor engineering. It will be used in connection with present graduate courses in nuclear engineering, and will be particularly valuable in thesis work, according to faculty members of the Division of Engineering.

Among the studies which can be undertaken with the new facility are the effects of radiation on materials placed within the reactor, the control of reactors, including how quickly they respond to changes in the control rods, the effect of changes in fuel, and heat transfer.

Students will be able to gain actual experience in operating the reactor, which is of a type designed especially for the training of students.

The reactor will be operated by the nuclear engineering group headed by Dr. Glenn Murphy, within the Division of Engineering. Dr. Robert Uhrig, who spent the Summer at the Argonne National Laboratory of the AEC in additional reactor



GRADUATE STUDENTS from many parts of the world have worked with Iowa State College's present subcritical nuclear assembly. Shown here are Lt. J. G. Ling *(left)*, U. S. Air Force, and J. F. Wilson *(right)*, both graduate students in nuclear engineering. The new reactor, also to be located in the Chemical Engineering West Building, will be considerably larger and more powerful than the present subcritical assembly.

Electrical Engineering Education

studies, will be active in the operating program.

Iowa State was one of six institutions in the Nation to receive grants for teaching reactors from the AEC recently.

The college was the second school in the United States to offer a graduate program with a major in the area of nuclear engineering. Starting with a single course in 1951, a sequence of courses was begun in the Fall of 1952, at which time the first master of science candidates were enrolled. Two degrees were conferred in the 1952-53 college year. During the past year, eight degrees were conferred, and a total of 25 students carried major work in nuclear engineering. Work is now offered through the doctor of philosophy level.

Stromberg-Carlson Scholarship Winners Named

Two Rochester high school seniors have been named winners of Stromberg-Carlson scholarships, it was announced by L. C. Holmes, director of research and chairman of the Scholarship Committee at Stromberg-Carlson, a division of General Dynamics Corporation.

Winners are H. J. Green III, and L. A. Rowell. The scholarships, which are given annually by Stromberg-Carlson to sons of employees, are for college courses in engineering or a related science. They pay full tuition, plus cash payments of $250 yearly to each scholarship holder.

Industry and Education Unite To Plan Engineering Program

The initial results of an unique partnership linking industry and education in the detailed planning of college curricula were announced in May at a dinner honoring 36 industrial leaders who comprise the Manhattan College Council on Engineering Affairs under the general chairmanship of C. E. Wilson, former president of General Electric Company.

More than 150 guests assembled in the Manhattan Club in downtown New York City heard Brother Augustine Philip, F.S.C., Manhattan College president, pay tribute to ". . . these distinguished men of industry who have worked so closely with our engineering faculty during the past year in examining engineering education generally and in giving greater vigor and meaning to the program of the College's School of Engineering."

The head of the only Roman Catholic college in New York State granting degrees in engineering disclosed that as of this September his institution would inaugurate a new program in chemical engineering and introduce major revisions in present offerings in civil, electrical, and mechanical engineering.

The College's new approach to the preparation of the future engineer will also permit qualified students majoring in each of the traditional engineering disciplines to elect a newly formulated nuclear science sequence. At the same time, the Manhattan Collge president revealed the institution's intention to seek support for the construction of a $4 million engineering center as the first phase of an over-all development program to be announced later this year.

Mr. Wilson, who presided at an executive committee meeting of the Council prior to the dinner, noted that trustee approval of the Council's formation in April 1957 was based on the belief that the revolutionary advances in science and technology over the past few decades made a re-examination of the form and substance of engineering education imperative. "The thoughtful study of the past 12 months is the culmination of more than 3 years of self-appraisal and gradual curricular change based on an analysis of the relationship of engineering to science in determining the proper function of an undergraduate school of engineering," he said.

The Manhattan College program, re-emphasizing the importance of humanities, mathematics, and science as the foundation of engineering education, rejects the inclusion of highly technical specialties as contrary to the proper objectives of an undergraduate college.

In a series of more than 20 meetings since September 1957, Council members and Faculty Committees redesigned the engineering curricula on the premise that sound undergraduate engineering education must establish fundamental concepts at the expense of specialization. According to Brother Philip, the candidate for a baccalaureate degree in engineering must understand that a 4-year college course can provide only the beginnings of an education, that first-line engineering design, research, or development requires advanced work on the graduate level, specialized training in industrial programs, and continuing self-development.

In the new Manhattan College engineering program, no more than 25% of the total degree requirements are to be found in courses within each field of specialization. More than one quarter of the entire program is in courses in theology and the humanities.

Another 25% of the entire curriculum is listed as providing ". . . a thorough grounding in mathematics, at least through differential equations, and the basic sciences of chemistry and physics, through modern physics."

The basic sciences are considered essential to all engineering students as the foundation of the engineering sciences or mechanics to which the remainder of the program is devoted. Fundamental concepts of solid mechanics, fluid mechanics, electrical circuits, and thermodynamics are described as bridging the gap between the basic sciences and engineering practice.

The new Manhattan College program provides a common course structure for all engineering students during their first two years, with the exception of those undergraduates electing the chemical engineering major. The student's decision as to his particular field of interest will

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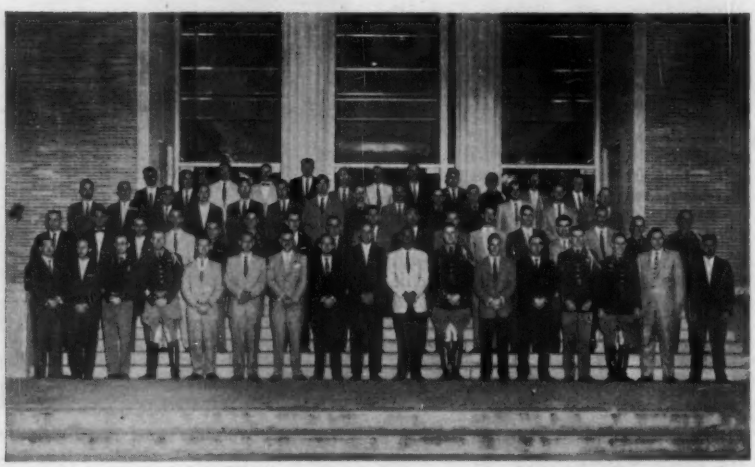


THE JOINT STUDENT BRANCH of the AIEE–IRE (Institute of Radio Engineers) at Texas A&M College during the academic year 1957-58 achieved 100% membership of the senior class for the second consecutive year. Each senior at Texas A&M experienced the benefits derived from membership in the Student Branch and appreciated the efforts of the Branch counselors—J. S. Denison for AIEE and H. C. Dillingham for IRE—and the entire electrical engineering staff, which resulted in making the Student Branch a source of new technical information and a place for professional development.

be delayed until the beginning of the junior year when he has had some experience in the engineering sciences upon which to base his selection. The student choosing the chemical engineering major will make his decision at the beginning of the second semester of the sophomore year.

Full year courses in higher mathematics, atomic and nuclear physics, and nuclear reactor theory form a nuclear science sequence which may be elected by properly qualifying students in the four majors.

Honorary Science Award Program Marks 25th Anniversary

The Bausch & Lomb Honorary Science Award program marked its 25th anniversary on June 17 with a Silver Anniversary luncheon before a group of distinguished scientists, educators, and Government officials at the Sheraton-Carlton Hotel in Washington, D.C.

C. S. Hallauer, president of the Bausch & Lomb Optical Company, delivered the welcome.

Vice-President Nixon presented special awards to two high school seniors who represented the 1958 winners of the Science Award chosen in more than 6,000 secondary schools in the United States. The students were Constance S. Rose of Charleston, W. Va., a 1958 graduate from Stonewall Jackson High School; and T. A. Hodgson, Jr., of Moorestown, N.J., a 1958 graduate from Moorestown High School.

The Vice-President also presented a special award to Dr. N. H. Nachtrieb, professor of chemistry at the University of Chicago, who represented the first Science Award winners of 1933.

The Bausch & Lomb Honorary Science Award program was inaugurated in 1933 to honor high school students who excel in the sciences and to encourage those talented young people to make science their careers.

A distinctive bronze medallion is made available without cost to any secondary school in the United States which offers three science subjects. The medal is awarded by the faculty of the school to the senior who has shown greatest progress in science.

Power Network Analyzer Gives Lehigh New Training Tool

The first electric network analyzer designed specifically for engineering education—a computerlike unit that can simulate the power system of an entire small town or public utility—went into service on May 1 at Lehigh University, Bethlehem, Pa.

The analyzer's first assignment was the study of a power flow problem furnished by planning engineers of Pennsylvania Power and Light Company.

A part of the Lehigh Valley transmission network, as planned for the future, was represented on the analyzer so that voltage adequacy could be predicted for various line conditions. The analyzer predicted that a specific line outage had such small effect on service that the utility will not plan to build a new line for reinforcement.

The new analyzer, termed a significant advance in technical training by officials of the engineering college, was dedicated during a "patchboard ceremony" at Lehigh's Packard Laboratory, where the room-size unit will serve as a laboratory tool for electrical engineering students and faculty, and for utilities and industrial firms.

University officials and professors and top executives of electrical utility companies and industrial firms attended the start-up ceremony which was moderated by Lehigh's vice-president and provost, Dr. H. A. Neville.

L. V. Bewley, Lehigh's dean of engineering, presented highlights in the evolution of the University's engineering school and its present day curriculum.

H. L. Buck, vice-president and general manager of I-T-E Circuit Breaker Company, Philadelphia, Pa., builder of the equipment, furnished background on his company and its relationships with engineering schools and electric utility companies.

The analyzer was dedicated when the first patchboard—the plug-in device that programs the analyzer for a specific study—was inserted by Prof. J. J. Karakash, head of Lehigh's department of electrical engineering, and G. E. Heberlein, I-T-E vice-president, engineering.

First of an expandable, building-block design developed for colleges and small private users by I-T-E, the Lehigh analyzer will let engineering students tackle electric power generation and distribution problems similar to those handled by public utilities on much larger and more complex network analyzers.

The analyzer will also be used by Lehigh faculty for advanced study and in connection with system problems encountered by local industry and power company engineers.

Ideally suited to college laboratory use, the analyzer is a flexible basic unit whose size and scope can be expanded later with the addition of more equipment.

This feature is extremely desirable for users who eventually need large analyzers but desire to acquire a small unit initially and expand size gradually.

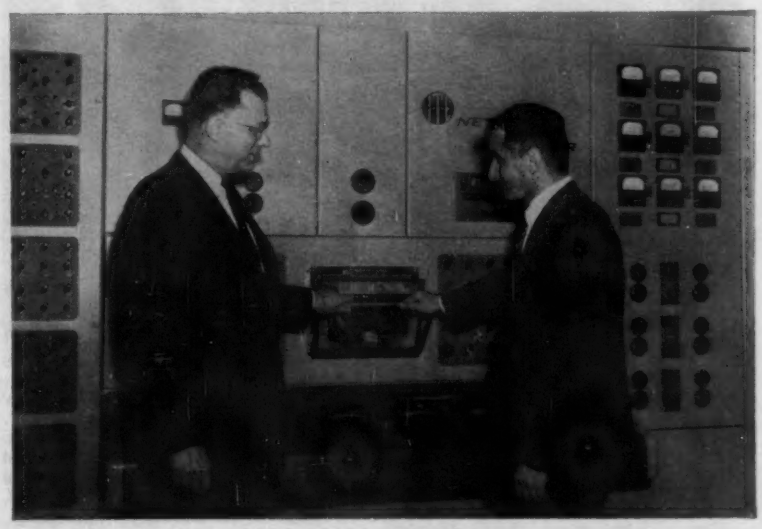
The basic-unit analyzer includes 3 generators and 24 circuit elements—a combination which is ideal for laboratory investigation of small power systems. Lehigh's analyzer incorporates 6 generators and 62 circuit elements.

If future expansion is desired, the basic unit control center can accommodate up to 21 generators and 400 circuit elements—extensive enough to permit analysis of a large electrical system.

The $75,000 Lehigh unit, which is 7 feet high, 2 feet deep, and 13 feet long, can, thus, eventually be expanded into a huge network analyzer which might cost as much as $200,000 or more.

The principle of operation of all such network analyzers is that of simulating various parts of electrical systems—generators, transmission and distribution lines, loads—through use of proper values of resistance, capacitance, and inductance.

A complete electrical system, from power source to such loads as homes,



FIRST PROBLEM is assigned to Lehigh University's new network analyzer during dedication ceremony at Packard Laboratory. The patchboard—the plug-in device that programs the analyzer for study of electric power problems—is inserted by G. E. Heberlein, vice-president, engineering, I-T-E Circuit Breaker Company, and Prof. J. J. Karakash, head of Lehigh's electrical engineering department.

Electrical Engineering Education

farms, and industrial plants, can be duplicated exactly with small electrical devices which act the same as their actual-system counterparts.

Expansion of loads and addition of new loads, such as those resulting from construction of new plants or buildings, or shifts in the setup of an existing system can be analyzed completely in the laboratory.

Simplicity of design and operation permits such network problems as load flow, short circuits, and transient or steady-state stability to be set up and run completely during an ordinary college laboratory period.

J. M. Pettit Named Dean of Stanford School of Engineering

J. M. Pettit, professor of electrical engineering and 1952 winner of the Institute of Radio Engineers (IRE) achievement award, became dean of the Stanford University School of Engineering September 1, President Wallace Sterling recently announced.

He will replace University Provost F. E. Terman (F '45), who has held the dual position since 1955. Dr. Terman will devote his full time to administrative duties as the second ranking academic officer of the University.

Dr. Pettit has a brilliant background in electronic circuitry, which earned him the Presidential Certificate of Merit for his work during World War II at the Government-sponsored Radio Research Laboratory at Harvard.

Honors Program in Engineering Sciences

There will be a new look in engineering education this Fall as an Honors Program in Engineering Sciences is injected into the Engineering Division curriculum at Swarthmore College. The new program, announced by President Courtney Smith, cuts across traditional departmental divisions of subject matter such as civil, mechanical, and electrical engineering, and stresses basic disciplines and fundamentals needed by all engineers with emphasis on the physical sciences and mathematics.

This increased emphasis on the basic scientific disciplines rather than on specialized technical subjects recognizes the unprecedented advance in the sciences in recent years. Increasingly, the engineer finds he must master knowledge of unexpected kinds. Thus, a mechanical engineer may need to know the principles of atomic radiations or the number theory. Dr. Smith predicts the program will give the engineering graduate the adaptability, the spirit of inquiry, and the fundamentals—emphasizing "why" rather than "how"—that will enable him to keep abreast of scientific developments and to contribute more effectively to a rapidly changing economy.

Industry–Education Advisory Council

AMONG PARTICIPANTS at the semiannual meeting of the Joint Industry–Education Advisory Council of the Science Manpower Project of Teachers College, Columbia University, on June 23, 1958, were: (*left to right*) Morris Meister, president, Bronx Community College; Dean S. M. Corey, Columbia Teachers College; A. M. Munger, employee relations division, Standard Oil Company of New Jersey; G. V. Grune, director of recruitment and college relations, Continental Can Company; W. W. Winter, supervisor of personnel research, American Electric Power Company; Howard Meyerhoff, executive director, Scientific Manpower Commission; W. T. Cavanaugh, executive secretary, Engineers Joint Council; and Prof. F. L. Fitzpatrick, director of the Science Manpower Project. The Science Manpower Project is designed to help improve the teaching of science in the nation's elementary and secondary schools. Centered in the department of teaching of science at Teachers College, the project is supported by 30 of the nation's larger industries. Its policies are guided by the Joint Industry–Education Advisory Council.

Caltech Students Receive Fulbright Grants

One recently graduated senior, five graduate students, and two members of the staff of the California Institute of Technology have been awarded educational exchange grants under the Fulbright Act for the 1958-59 academic year

J. C. Fineman of Shaftsbury, Vt., who received his B.S. degree in physics in June, will study at the University of St Andrews in the United Kingdom.

P. M. Moretti of Santa Barbara, Calif. who is working for his master's degree in mechanical engineering, will continue his studies at Technische Hochschule Darmstadt, Germany.

A. W. Trivelpiece of Altadena, Calif. received his Ph.D. in E.E. in June and will continue his postdoctoral study in physical electronics at Technological University, Delft, The Netherlands.

K. R. King of Phoenix, Ariz., who is working for his Ph.D., will continue his studies in mechanical engineering and physical metallurgy at Technische Hochschule, Stuttgart, Germany.

E. A. Flinn, III, of Tulsa, Okla., studying for his Ph.D. in geophysics, will continue his work at the Australian National University, Canberra, Australia.

William Zimmerman, Jr., of Wyncote, Pa., received his Ph.D. in physics and will continue his postdoctoral studies in low temperature physics at Leiden University The Netherlands.

Dr. Guido Munch, associate professor of astronomy, will conduct research in astrophysics at the Max-Planck Institute for Physics, Munich, Germany.

Dr. John Laufer, research specialist at the Caltech Jet Propulsion Laboratory, will conduct physics research at the Polytechnic Institute in Turin, Italy.

First Engineering Scholarship Awarded by Anchor Metals, Inc.

F. H. Booth, Jr., May graduate of Lawrence D. Bell High School near Fort Worth, Texas, has been named the recipient of the first 4-year engineering scholarship to be awarded annually by Anchor Metals, Inc., of Hurst.

INSTITUTE ACTIVITIES

NIGHT VIEW of the Golden Triangle of Pittsburgh, Pa., where the 1958 Fall General Meeting of the Institute will take place October 26-31.

Pittsburgh Welcomes 1958 Fall General Meeting of AIEE

RESEARCH, atomic power, and the Pittsburgh Redevelopment and Bicentennial will be some of the highlights of the 1958 Fall General Meeting of the Institute. Beginning on Sunday, October 26, and continuing through Friday, October 31, an extensive series of technical sessions, outstanding inspection trips, social activities, and entertainment for the ladies will make up a very full week of events.

Headquarters for the meeting will be the Penn-Sheraton Hotel. This large modern hotel is located in the heart of the Golden Triangle and looks out on the new Mellon Park Square. Department stores are close at hand and the new and beautiful Gateway Center is within easy walking distance. Although the observance of Pittsburgh's Bicentennial does not officially begin until Thanksgiving Day, visitors will see many evidences of this celebration which commemorates the day when General Forbes, having driven the French from Fort Duquesne, named the land at the Point "Pittsburgh."

Hospitality

On Sunday, October 26, from 4:00 p.m. to 6:00 p.m., a Welcome Tea will be held in the Monongahela Room on the 17th floor of the hotel. This tea, sponsored jointly by the Ladies Committee and the Pittsburgh Section, provides an opportunity for renewing old acquaintances and meeting new friends. The Ladies' Hospitality Suite will be in Room 1666 (Presidential Suite). This room will be headquarters for the ladies throughout the week.

General Session

The theme of the general session, to be held at 2:00 p.m. on Monday, October 27, in the ballroom, will be "Atomic Energy and the Shippingport Project." The principal speaker. J. K. Hodnette, executive vice-president, Westinghouse Electric Corporation, will talk on "Industry and the Atom Today."

A feature of this session will be the presentation of the AIEE Education Medal to Prof. J. F. Calvert, head, electrical engineering department, University of Pittsburgh. The history of the medal will be presented by W. R. Brownlee, chairman of the Recognition Awards Committee, and the career of the medalist by Dr. A. B. Bronwell, president, Worcester Polytechnic Institute. Presentation of the medal and certificate will be made by AIEE President L. F. Hickernell. The address of welcome will be made by the Honorable D. L. Lawrence, Mayor, City of Pittsburgh.

Luncheons

Two important luncheons are scheduled to be held at noon on Tuesday and Thursday in the ballroom.

The Tuesday lunch will have as its theme the "Pittsburgh Redevelopment and Bicentennial." The speaker will be A. W. Schmidt, who is president of the Allegheny Conference on Community Development. Mr. Schmidt is vice-president and governor of T. Mellon and Sons and is actively engaged in many public service projects. He will relate the events which have brought Pittsburgh the name of "Renaissance City of America."

The Thursday luncheon will follow the theme of "Research in the Pittsburgh Area." The directors of research of the many companies in this area will attend this meeting. As a fitting climax to this gathering, the John Fritz Medal will be awarded to Dr. M. J. Kelly, president, Bell Telephone Laboratories, Inc. Dr. Kelly's acceptance speech will conclude the luncheon hour.

The price of each of these luncheons is $3.75. Tickets may be reserved by using

Courtesy Photo Associates

THE OFFICIAL SEAL for the Pittsburgh Bicentennial Celebration, which begins on Thanksgiving Day, 1958, shows the Three Rivers, The Point, The Golden Triangle, The Pentagonal Fort Pitt, and a living tree, symbolizing a growing city—Pittsburgh. The Tuesday luncheon during the AIEE Fall General Meeting will have as its theme "Pittsburgh Redevelopment and Bicentennial."

TOD Forum

The usual Forum of Technical Committee Chairmen, Vice-Chairmen, Technical Operations Department (TOD) District Representatives, TOD members, and others concerned with TOD operations, will be held in the Penn-Sheraton Hotel, Pittsburgh, Pa., at 7:30 p.m., on Thursday, October 30, 1958, in connection with the AIEE Fall General Meeting. The room will be announced in the program.

As is customary at Fall General Meetings, the topics to be introduced for discussion will be aimed at the "education" of Technical Committee Chairmen and Vice-Chairmen, particularly those who were initially inducted into office during the 1958-59 Institute year.

the registration card which accompanies the meeting notice.

Young Engineer in the Power Industry

An outstanding technical session, aimed particularly to help undergraduates and young engineers, is being planned to present the views and experiences of electrical engineers in the power field. The speakers will illustrate their experience with a variety of unique problems which almost daily confront engineers in finding better ways to generate, transmit, and utilize electric power. They will expose the challenges and opportunities for young engineers in the power industry. The subject will be presented in a compact manner and give a realistic picture of engineering in the power field which will be helpful to the undergraduate and the newly graduated engineer in choosing his field of employment. A discussion will follow and students' and educators' questions will be welcome. This session is scheduled for Tuesday morning, October 28.

Technical Program

A large and varied technical program has been planned which will be excellent in all areas. Paralleling the inspection trips to the Westinghouse Atomic Power Division and to the Shippingport Atomic Power Station, there will be five sessions which deal with atomic power. A tentative program of technical sessions follows. (Titles of papers will be printed later.)

Monday, October 27

9:00 a.m. Morning Sessions
Data Communications
Nucleonic and Radiation Instruments
Management
Research
Electronics
Mining Industry

2:00 p.m. General Session

Tuesday, October 28

9:00 a.m. Morning Sessions
Communication Switching Systems
Transmission and Distribution
Power Generation
Feedback Control Systems and Metal Industry
Industrial and Commercial Power Systems
Solid-State Devices and Semiconductor Metallic Rectifiers
Mining Industry
Safety

2:00 p.m. Afternoon Sessions
Transmission and Distribution
Feedback Control Systems
Industrial and Commercial Power Systems
Solid-State Devices and Semiconductor Metallic Rectifiers
Metal Industry
Basic Sciences
Computing Devices and System Engineering
Education

8:00 p.m. Feedback Control Systems Panel Discussion

Wednesday, October 29

9:00 a.m. Morning Sessions
Communication Theory
Metal Industry
Rotating Machinery and Relays
Land Transportation
Feedback Control Systems
Power Generation and Nucleonics
Transmission and Distribution

2:00 p.m. Afternoon Sessions
Communication Theory
Metal Industry
Rotating Machinery
Land Transportation
Relays and Transmission and Distribution
Insulated Conductors
Power System Communications

Thursday, October 30

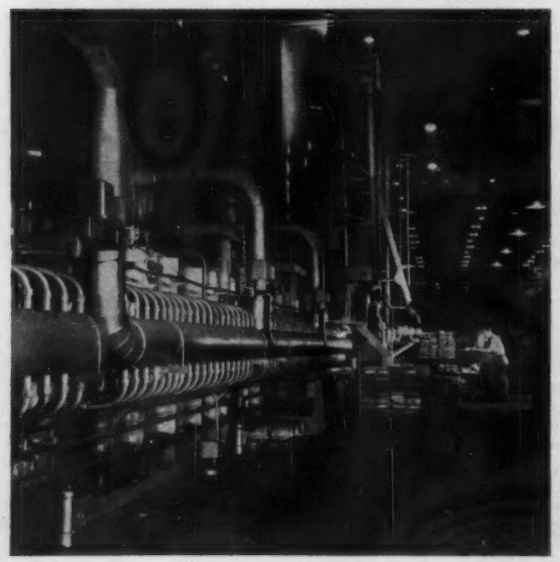
9:00 a.m. Morning Sessions
Radio Communication Systems
Rotating Machinery
System Engineering
Industrial Control
Substations
Power Generation and Nucleonics
Magnetic Amplifiers
Computing Devices and Feedback Control Systems
Electrical Insulation

2:00 p.m. Afternoon Sessions
Radio Communication Systems
Rotating Machinery
System Engineering
Industrial Control
Substations
Power Generation and Nucleonics
Feedback Control Systems
Computing Devices

Friday, October 31

9:00 a.m. Morning Session
Rotating Machinery
Transformers
Switchgear
Computing Devices
Protective Devices
Wire Communication Systems
Substations

2:00 p. m. Afternoon Session
Rotating Machinery
Transformers
Switchgear
Computing Devices
Protective Devices
Electrical Insulation



A CONTINUOUS galvanizing line at Irvin Works, Dravosburg, Pa., of U. S. Steel, one of two such units recently installed at this plant, galvanizes heavy gauge steel used in making household appliances, railroad cars, roofing, automotive parts, etc. The wide strip of steel is processed through a hot bath of molten zinc to receive its galvanized coating. These works will be visited on Tuesday morning, October 28, during the Fall General Meeting.

Golden Triangle Frolics

On Wednesday evening, October 29, the Golden Triangle Frolics will be held in the ballroom on the 17th floor of the hotel. The evening promises to be a very enjoyable one for the members and their ladies. After dinner there will be an excellent floor show followed by dancing. Tickets will be $11.50 each. A reservation card will accompany the meeting notice and it is recommended that it be forwarded as early as possible to avoid disappointment. Dress will be informal.

Hotel Reservations

All reservations for rooms should be made through the Penn-Sheraton Hotel which has set aside a large number of rooms for this meeting. When no more rooms are available, the hotel will automatically forward reservation requests to another nearby hotel through the Pittsburgh Convention Bureau. A confirmation will be mailed to members directly by the hotel accepting the reservation. If

rooms at rates requested are not available, a room at the next higher rate available will be assigned.

L. W. Mahler is chairman of the Sleeping Rooms Subcommittee, and should be contacted in case assistance is needed. Address requests to L. W. Mahler, Sleeping Rooms Subcommittee, Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh 22, Pa.

A hotel reservation and rate card (no postage required) will accompany the meeting notice. As indicated, it should be sent direct to the hotel. If the card is mislayed or lost, write to: Office of the General Manager, Penn-Sheraton Hotel, PO Box 1978, Pittsburgh, Pa. Please indicate on reservation cards the time of arrival and departure. If it is necessary to correspond with the hotel regarding room reservations, please mail a copy of the letter to Mr. Mahler. If an acknowledgement from the hotel is not received after a reasonable time, write to the hotel, sending a copy to Mr. Mahler.

Rates for rooms at the Penn-Sheraton are as follows.

Single Bed, bath, one person, per day	$ 8.50 to $12.50
Double Bed, bath, two persons, per day	12.50 to 15.50
Twin Beds, bath, two persons, per day	13.50 to 20.00
Third Person in room	3.00 additional
Family Plan—Children under 14	Free
Suites—parlor and twin bedroom, bath	27.00, 32.00, 37.00
Suites—parlor and two twin bedrooms, bath	50.00, 55.00

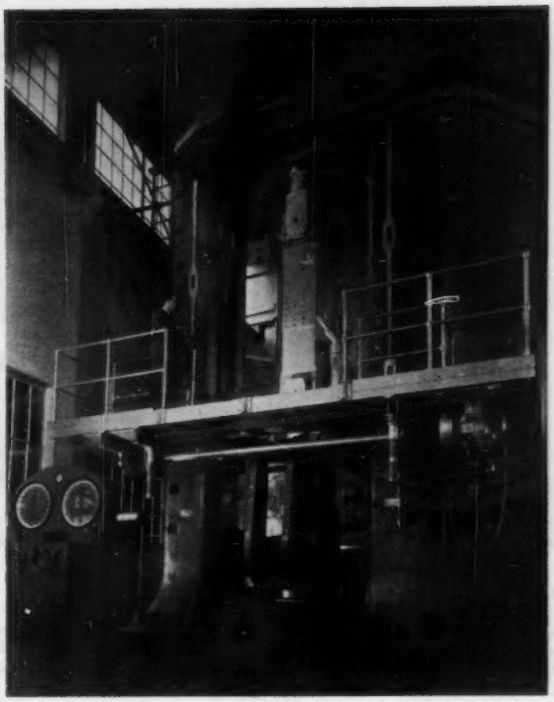
Reservations must be received by the Penn-Sheraton not later than October 11. Members are urged to mail their reservations as early as possible so as to be assured of getting their desired accommodations. Every effort will be made by the local committee and the Convention Bureau to handle requests received after the deadline but this may prove difficult after the hotels have released rooms which were held for the meeting.

Inspection Trips

Eight inspection trips have been scheduled to points in the Pittsburgh district for those attending the Fall General Meeting. In line with the theme of the meeting, they will include visits to research centers and to other interesting industrial operations. Members are urged to make advance reservations for these trips using the registration card accompanying the meeting notice. Otherwise, arrangements should be made at the inspection trips desk immediately after registration. Transportation will be required for all trips and a uniform charge of $2 per person will be made.

U.S. Steel Corporation, Irvin Works, Tuesday Morning. This one and one-half hour tour covers the operations of the cold reduction mills, the continuous strip mill, continuous galvanizing lines, electrolytic tinning line, annealing furnaces, pickling lines, and tinning stocks. Some of the latest developments in steel-making processes are to be seen here.

Westinghouse Electric Corporation, Tuesday Afternoon. Tour "A"—East Pittsburgh Plant. The largest of the divisions of the Westinghouse Electric Company, this plant manufactures the heavier apparatus lines of the electrical industry. Of particular interest are the service facilities, including one of the world's largest network calculators and a high power laboratory "proving ground" for power apparatus of the future.



DURING the Fall Meeting, an inspection trip will be made to the Research Center of the Aluminum Company of America. Largest piece of equipment in the New Kensington laboratories is this 3 million-pound capacity Templin precision metal working machine. Shown is a riveted joint being tested in tension. With a capacity of 2 million pounds in compression and 1 million pounds in tension, it can apply loads at speeds up to 36 inches per minute. Used both for testing and for development of production processes, the Templin machine is one of the largest and most powerful precision machines in the world.

Photo Courtesy Aluminum Company of America

Tour "B"—Atomic Power Division, Forest Hills and Waltz Mill. Basic engineering design for all atomic reactors is developed at Forest Hills: the experimental nuclear tests involving the designs are conducted at the criticality facility at Waltz Mill. Fuel element experiments in connection with the Yankee Atomic Electric Project are also under way at Waltz Mill. The effects of radiation on materials will be determined at the Westinghouse testing reactor (WTR), which is being constructed adjacent to the criticality facility. This visit includes the Westinghouse Reactor Evaluation Center.

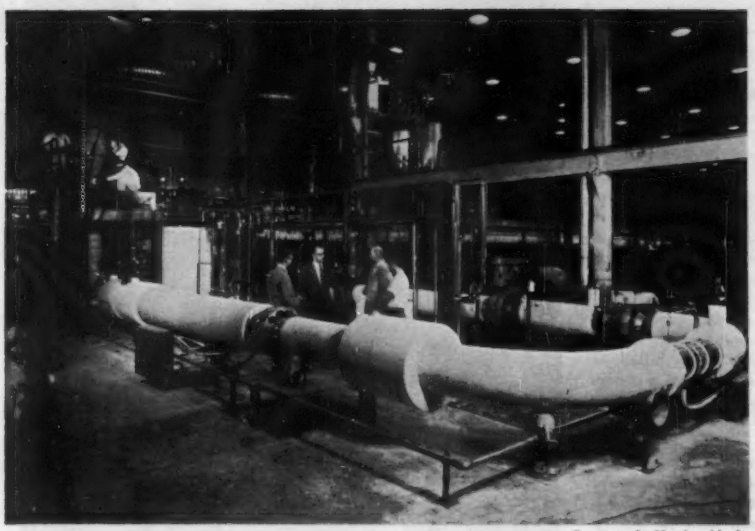
Duquesne Light Company Shippingport Atomic Power Station, Wednesday Morning and Afternoon. The world's first full-scale electric power plant devoted exclusively to peacetime needs utilizing an atomic reactor as its primary heat source. While experimental reactors of many different types have been built on a small scale, the technology of the pressurized-water reactor—the same type used on the submarine *Nautilus*—is by far the most advanced. The plant has a net output in excess of 60,000 kw at 600 pounds steam pressure. An informative trip, a first step into the world of tomorrow.

U.S. Steel Research Center, Monroeville, Thursday Morning. This is one of the largest laboratories for steel research in the world. Nearly 1,000 technical and scientific personnel are engaged in fundamental and applied research. Subjects under investigation include such widely diversified problems as new processes for upgrading coal chemicals and the study of dislocations in the atomic structure of steel.

Aluminum Company of America Research Laboratories, New Kensington, Thursday Afternoon. The Alcoa Research Laboratories—one of the world's largest light-metals research facilities—was established in 1918. The Research Laboratories now consists of 15 divisions; 12 of these are located in New Kensington. The research center covers 64 acres and occupies 172,000 square feet of floor space in three buildings. The aluminum industry's major alloys—of which over 70 are now in use—were discovered by the laboratories' scientists and engineers. Constant research is going on here to uncover additional processes to widen the ever-expanding use of this versatile light metal.

Westinghouse Research Laboratory, Churchill Borough, Friday Morning. Dedicated in 1956, these laboratories employ 800 people who find the country-like atmosphere particularly conducive to the intensive pioneering research for which Westinghouse is noted. "Blue Sky," Research-of-the-Future, occupies 30% of the total man hours expended. Some 50% of the time is spent in basic research. Government oriented research associated with reactor development, communications, and detecting devices is also carried on at the laboratories. Here are to be found the latest developments in laboratory equipment and laboratory planning.

Pennsylvania Railroad, Conway Yard, Friday Afternoon. This is one of the world's largest and most modern fully automatic freight car classification yards. Through Conway, passes most of the



Courtesy J. M. Arnold, Jr.

AN INSPECTION TRIP will be made during the Fall General Meeting, on Tuesday afternoon, October 28, to the Westinghouse Atomic Power Department at Forest Hills, Pa. This department is devoted to the research, development, application, and manufacture of commercial nuclear power reactors. Shown above is half-scale test loop involved in the Westinghouse–Pennsylvania Power & Light homogeneous reactor plant development program.

enormous east-west traffic between the Eastern Seaboard, Great Lakes, and Middle West.

The efficiency of automation is apparent here, where 9,000 cars per day are sorted and classified according to their destination. The system uses electronic analog computers, radar, automatic switching, inductive trainphone, cab signals, electronic scales, punched-card accounting machines, micro-talkie radios, intercom and paging systems, automatic floodlights, pneumatic tubes, teletypewriters, and tape recorders.

This trip is sponsored by the Pennsylvania Railroad Company and Union Switch and Signal, a division of Westinghouse Airbrake Company, manufacturers of the VELAC Automatic Classification Yard System.

Alcoa Exhibit

During the five days of the Fall Meeting, the entire main entrance and main lobbies of the Alcoa Building will be used for a display of aluminum, electrical, and electronic equipment for the utility and industrial fields. This display, showing representative products of all the major equipment manufacturers, is expected to be the most complete group of such equipment ever collected.

Ladies Program

The Ladies Activities Committee, headed by Mrs. Tomlinson Fort, has arranged a full calendar of events. Headquarters for the ladies will be the Presidential Suite of the hotel, where a coffee hour will be observed each morning, Monday through Friday. The scheduled activities include: Monday—afternoon tea and tour of Alcoa Building; Tuesday—luncheon at Longue Vue Country Club; Wednesday—bridge and luncheon at Utility Hall (Duquesne Light Company); Thursday—tour of University of Pittsburgh with tea and visits to Heinz Chapel, Stephen Foster Memorial Hall, and University Nationality Rooms.

Registration

Advance registration for the Fall General Meeting is not required. Registration fees are $5 for members and $8 for nonmembers. Families and student members will not be charged a registration fee. The registration desk will be located in the Sky Room on the 17th floor. Information and ticket sales will be established in the corridor just outside the Sky Room.

A reservation card will be enclosed with the meeting notice which should be used to indicate intentions regarding the Golden Triangle Frolics ($11.50), Tuesday and Thursday Luncheons ($3.75 each), Inspection Trips ($2.00 each), and Ladies Events (free). This card should be mailed to M. P. Getting, Chairman, Registration, 1958 Fall General Meeting, Allis-Chalmers Manufacturing Co., Columbia & Preble Avenues, Pittsburgh 33, Pa. Make checks payable to "1958 Fall General Meeting."

Committee

Members of the 1958 Fall General Meeting Committee are: A. A. Johnson, chairman; Dixon Lewis, vice-chairman: W. H. Osterle, secretary; A. P. Hayward, treasurer; E. L. Harder, program; F. H. Schlough, publicity; M. P. Getting, registration; C. N. Clark, hotels; E. M. Hays, inspection trips; G. H. Phillips, papers; Pascal Beckjord, hospitality; Mrs. Tomlinson Fort, ladies; E. S. Reeser, entertainment; E. M. Williams, student activities; W. R. Harris, Pittsburgh Section.

National Power Conference Committee

Fay Foto Service, Inc.

MEMBERS of the Arrangements Committee for the 1958 National Power Conference sponsored by AIEE and The American Society of Mechanical Engineers (ASME), September 28-October 1, in Boston, Mass., are: (*front row, left to right*) R. B. Meader, publicity, chairman; W. E. Hopkins, technical events, chairman; F. B. Haeussler, vice-chairman; E. A. Barry, general chairman; L. J. Weed, finance, vice-chairman; Alton Kirkpatrick, secretary; C. R. Westerway, hotel reservations, chairman; (*rear row, left to right*) N. Stadtfeld, Jr., hotel reservations, vice-chairman; H. W. Kinsel, registration, vice-chairman; S. S. Perry, reception, vice-chairman; R. R. Peatfield, printing and signs, chairman; K. G. Barnhill, publicity, vice-chairman; W. Boynton, editor, ASME *Pinion*; S. B. Farnham, technical events, vice-chairman; W. S. C. Henry, plant trips, chairman.

AIEE Future Meetings

AIEE-ASME National Power Conference*
Statler Hotel
Boston, Mass.
September 29-October 1, 1958

26th Annual Meeting of ECPD
Sheraton-Jefferson Hotel
St. Louis, Mo.
October 9-10, 1958

AIEE-IRE-EIA-SMPTE National Electronics Conference*
Hotel Sherman
Chicago, Ill.
October 13-15, 1958

Machine Tools Conference*
Statler Hotel
Hartford, Conn
October 13-15, 1958

Farm Electrification Conference*
Monteleone Hotel
New Orleans, La.
October 20-22, 1958

Fall General Meeting*
Penn-Sheraton Hotel
Pittsburgh, Pa
October 26-31, 1958

Fall Textile Conference*
North Carolina State College
Raleigh, N. C.
October 30-31, 1958

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Pick-Nicollet Hotel
Minneapolis, Minn.
November 19-21, 1958

Magnetism and Magnetic Materials Conference*
Sheraton Hotel
Philadelphia, Pa.
November 17-20, 1958

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)*
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958

AIEE-IRE Second National Symposium on Communication Systems (Exhibit)*
Colonial Inn-Desert Ranch
St. Petersburg, Fla.
December 3-5, 1958

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Oct. 29, CPMs—Nov. 7)

Winter General Meeting
Statler Hotel
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Nov. 3, ‡CP Syn.—Nov. 18, CPMs—Nov. 28)

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 12-13, 1959
(Final date for †TP—Nov. 13, ‡CP Syn.—Nov. 28, CPMs—Dec. 9)

AIEE-IRE-ACM Western Joint Computer Conference
Fairmont Hotel
San Francisco, Calif.
March 3-5, 1959
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 19, CPMs—Dec. 29)

EJC Nuclear Congress
Municipal Auditorium
Cleveland, Ohio
April 5-10, 1959
(Final date for †TP—Nov. 28)

South East-South Central District Meeting
District Plaza Hotel
Atlanta, Ga
April 8-10, 1959
(Final date for †TP—Jan. 8, DPMs—Feb. 2)

Electric Heating Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 14-15, 1959
(Final date for †TP—Jan. 14, ‡CP Syn.—Jan. 30, CPMs—Feb. 9)

Electrical Problems in the Cement Industry Conference
Allentown, Pa.
April 16-17, 1959
(Final date for †TP—Jan. 16, ‡CP Syn.—Jan. 30, CPMs—Feb. 10)

Recording and Controlling Instruments Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 20-21, 1959
(Final date for †TP—Jan. 20, ‡CP Syn.—Feb. 3, CPMs—Feb. 13)

East Central District Meeting
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs—Feb 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 6, CPMs—Feb. 16)

Empire District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs—Feb. 23)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
May 6-8, 1959
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 20, CPMs—March 2)

AIEE-ASME-IRE Automatic Techniques Conference
Pick-Congress Hotel
Chicago, Ill.
May 11-13, 1959
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 24, CPMs—March 6)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs—March 13)

AIEE-ISA-ARS-IAS National Telemetering Conference
Brown Palace and Cosmopolitan Hotel
Denver, Colo.
May 24-27, 1959
(Final date for †TP—Feb. 23, ‡CP Syn.—March 10, CPMs—March 20)

Summer and Pacific General Meeting
Olympic Hotel
Seattle, Wash.
June 21-26, 1959
(Final date for †TP—March 23, ‡CP Syn.—April 7, CPMs—April 17)

Petroleum Industry Conference
Wilton Hotel
Long Beach, Calif.
August 25-27, 1959
(Final date for †TP—May 27, ‡CP Syn.—June 12, CPMs—June 23)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

**Transactions and conference papers must conform to the requirements in *Authors Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.**

Three Distinguished Speakers Scheduled for 1958 NEC in Chicago

THREE distinguished leaders—one from the military, one from Government, and one from private industry—will speak at luncheons during the 14th annual National Electronics Conference (NEC) at the Hotel Sherman, Chicago, Ill., October 13-15, 1958. They are: Gen. J. B. Medaris, commanding general, U.S. Army Ordinance Missile Command, Redstone Arsenal in Alabama, the first commander of this new Army organization, who will speak on Monday, October 13; D. B. Quarles, Deputy Secretary of Defense for the United States, who will address an NEC luncheon on Tuesday; and Dr. Simon Ramo, vice-president of Ramo-Wooldridge Corporation, known for his far-reaching capabilities in electronics and missile-space technology, who will speak on Wednesday.

NEC's 3-day program includes over 100 technical papers as well as panel and tutorial discussions, according to Conference President J. H. Enenbach, supervising engineer for Illinois Bell Telephone Company. More than 10,000 scientists, engineers, and educators are expected to attend. The technical sessions, Mr. Enenbach said, will provide up-to-the-minute coverage on research, development, and application in the broad field of electronics.

More than 250 commercial exhibits, highlighted by displays of new electronic developments and devices, also are scheduled.

Sponsors of NEC are: AIEE, Illinois Institute of Technology, the Institute of Radio Engineers, and Illinois and Northwestern Universities. Participants are: Michigan, Michigan State, Notre Dame, Purdue, Wayne State, and Wisconsin Universities, Electronic Industries Association, and the Society of Motion Picture and Television Engineers.

The tentative technical program for the Conference follows.

Monday, October 13

Morning Sessions

Transistors I

PNxN Switches. *J. A. Hoerni, R. N. Noyce,* Fairchild Semiconductor Corp.

Pulse Circuits Using Avalanche Transistors. *D. S. Gage,* Northwestern University

Transistor-Magnetic Pulse Generator. *Arthur Krinitz,* Massachusetts Institute of Technology

Transistor-Diode Logic. *R. A. Carlsen,* University of Michigan

Servomechanisms I

The Analysis of Closed-Loop Sampled-Data Systems with Nonnegligible Pulse Width. *G. J. Murphy,* Northwestern University

Transient Response of a Servomechanism with Backlash. *J. B. Kreer, G. H. Fett,* University of Illinois

Vacuum Tubes and Transistor Circuits in Control Systems. *D. P. Brown, J. J. Lang,* Michigan State University

On a Compromise Approach to Servomechanism Dynamic Response Optimization. *C. L. Smith,* Minneapolis Honeywell, Inc.; *C. T. Leondes,* University of California at Los Angeles and the Ramo-Wooldridge Corp.

Antennas

A Broad Band Circularly Polarized Antenna. *R. M. Smith,* Radio Corporation of America

Surface Wave Dielectric Disc Antenna. *K. E. Niebuhr,* Rome Air Development Center; *E. H. Scheibe,* University of Wisconsin

Theoretical Radiation Pattern and Impedance of a Flush Mounted Coaxial Aperture. *G. I. Cohn, G. T. Flesher,* Illinois Institute of Technology

A Radio Astronomy System. *George Doundoulaskis,* General Bronze Corp.

Audio

The Electro-Acoustic Transducer and Its Application to Sonar Systems. *George Rand, John Devine,* Sperry Gyroscope Company, Sperry Rand Corporation

An Improved Method for the Measurement of Nonlinear Audio Distortion. *J. S. Aagaard,* Northwestern University

The Design of Electronic Musical Instruments. *R. E. Peterson,* Peterson Electro-Musical Products

Effects of Practical Transformers on Output-Tube Performance in Hi-Fi Amplifiers. *Leonard Kaplan,* Radio Corporation of America

A Two-Way Stereophonic Amplifier. *B. B. Bauer, John Hollywood, George Maerkle,* CBS Laboratories

Luncheon

Address: Gen. J. B. Medaris, Redstone Arsenal, Huntsville, Ala.

Afternoon Sessions

Tutorial Session on Automatic Navagation

Principles of Inertial Navigation. *Walter Wrigley, W. R. Markey, John Hoborka,* Massachusetts Institute of Technology

Doppler Radar Navigation. *F. B. Berger,* General Precision Laboratory, Inc.

Combined Doppler Radar and Inertial Systems. *D. B. Duncan,* Autonetics-North American Aviation, Inc.

Filter Design

High Frequency Transistor Filter Synthesis. *L. M. Vallese,* Polytechnic Institute of Brooklyn

The General Theory of Comb Filters. *G. T. Flesher, G. I. Cohn,* Illinois Institute of Technology

A VHF-UHF Band-Pass Filter Employing Striplines and Capacitors as Circuit Elements. *A. C. Todd,* Armour Research Foundation; *R. P. Siskind,* Purdue University

The Simplest Crystal Filter with Symmetrical Frequency Response. *T. R. O'Meara,* Hughes Aircraft Company

Solid State

Switching VHF Power with Semiconductor Diodes. *R. H. Mattson, S. H. Liu,* Iowa State College

The Response of a Germanium Phototransistor to Light Pulses of Very High Intensity and Short Duration. *R. Frerichs, E. Muly,* Northwestern University

Remotely Controlled Electroluminescent Totalizing Display. *R. C. Lyman, C. I. Jones, A. Leger,* Westinghouse Electric Corporation

Lumistors: Their Applications and Their Limitations. *C. F. Spitzer,* Lockheed Aircraft Corp.

Microwaves I

General Method of Analyzing Bilateral Two-Port Networks from Three Arbitrary Impedance or Reflection Coefficient Measurements. *E. Folke Bolinder,* Air Force Cambridge Research Center

On the Analysis of Lossless Symmetrical Waveguide Junctions. *R. S. Potter,* Naval Research Laboratory

A Low Reflection Dielectric Waveguide Stepped Taper. *R. A. Whiteman, H. Zucker, C. M. Knop,* Armour Research Foundation

Rapidly Tunable Wide Range UHF Cavity. *T. Douma,* Radio Corporation of America

Tuesday, October 14

Morning Sessions

International Geophysical Year

Dr. A. M. Peterson, Stanford University

Dr. W. H. Pickering, California Institute of Technology

Dr. A. H. Shapley, Bureau of Standards

Transistors II

Transistor Pulse Width Control Amplifier with Reactive Load. *G. T. Flesher,* Illinois Institute of Technology

Some Methods of Measuring Power Loss in Switching Transistors. *G. M. Ettinger,* Marconi Instruments Limited, London, England

Switching Time Calculations for Diffused Base Transistors. *V. H. Grinich, R. N. Noyce,* Fairchild Semiconductor Corp.

A Transistorized Amplitude Distribution Analyzer Employing Digital Techniques. *D. Hoffman, E. Schutzman,* New York University

Design Considerations and Operational Limitations of Solid Electrolyte Tantalum Capacitors. *P. D. Alley, Archie Broodo, C. D. Orrall,* Texas Instruments Inc.

Servomechanisms II

Application of Direct-Drive Sermomotors to Gyro Platforms. *J. G. Nelson,* Minneapolis-Honeywell, Inc.

Effect of Variation in Carrier Frequency on the Performance of Carrier Control Systems Utilizing Two-Phase Servo Motors. *E. W. Mehelich, G. J. Murphy,* Northwestern University.

A New Method of Precision Control for Large Antenna Systems. *Arthur Fein,* General Bronze Corp.

Probability of Continuous Tracking in the Presence of Random Noise. *F. E. Alzofon,* Ames Aeronautical Laboratory, *S. E. Rauch,* University of California

Instrumentation

A System for the Accurate Determination of Ultrasonic Velocity in Solids. *R. L. Forgacs,* Ford Motor Company

Improved Methods of Oscillograph Pulse Photography. *Thomas Henion,* New York University

A Wide-Band Electrometer Preamplifier. *P. J. Rosen,* Ford Motor Company

An Instrumentation Type Crossbar Switch. *Kurt Enslein,* Brooks Research, Inc.

Resistivity Measuring Techniques in Semiconductors. *H. G. Rudenberg,* Transistron Electronic Corp.

Luncheon

Address: D. A. Quarles, Deputy Secretary of Defense, Washington, D. C.

Afternoon Sessions

Panel Discussion—Role of the Laboratory Program in Engineering Education

J. Gershon, DeVry Technical Institute

T. F. Jones, Jr., Purdue University

R. H. Davis, Westinghouse Electric Corporation

D. E. Wendel, Hughes Aircraft Company

Network Theory

Synthesis Applications of Dominant and Paramount Matrices. *Paul Slepian, Louis Weinberg,* Hughes Research Laboratories

Topological Formulas for Nonreciprocal Networks and Networks with Transformers. *Wataru Mayeda,* University of Illinois

The Digital Computer as a Tool for Network Analysis. *M. B. Reed, C. V. Anderson,* Michigan State University

A Simple Class of Equivalent Networks. *S. L. Hakami,* University of Illinois

Linear Graph Representation of Multiterminal Elements. *H. E. Koenig, Myril B. Reed,* Michigan State University

Microwaves II

On the Transition from Fast Waves to Slow Waves in the Shielded Dielectric Waveguides. *Hiroshi Kikuchi,* Ministry of International Trade and Industry, Tokyo, Japan

Oversize Circular Electric Waveguide Components. *A. C. Todd, R. E. Saxe,* Armour Research Foundation

Influence of Sea Level Cosmic Radiation on Power Breakdown of Air Filled Waveguide. *S. W. Lichtman,* Hughes Aircraft Company

The Design of a Single-Layer Microwave Absorbing Material. *D. L. Waidelich,* University of Missouri

Noise and Data Smoothing

Generalized Error Functions for Nonlinear Systems with Random Inputs. *H. R. Leland,* University of Wisconsin

Approximation of Autocorrelation Functions by a Series of Damped Exponential Functions. *D. T. Friest, R. G. Brown,* Iowa State College

Design of a Delay Line for an Analog Correlator. *T. B. Benedict, H. S. Min, V. C. Rideout, W. G. Swift,* University of Wisconsin

Overmodulation of a Carrier by Sine Wave and Gaussian Noise. *D. R. Rothschild,* University of Michigan

Wednesday, October 15

Morning Sessions

Engineering Writing and Speech

How AIEE Views Your Technical Paper. *C. S. Rich,* AIEE

How the IRE Views Your Technical Paper. *E. K. Gannett,* Institute of Radio Engineers

How the Technical Publicity Department Views Your Technical Paper. *E. E. Grazda, Electronic Design* and *Electronic Week*

How the General Press Views Your Technical Paper. *Roy Rowan, Time-Life*

Computers

Description and Results of Experiments with Speech Using Digital Computer Simulation. *E. E. David, Jr., M. V. Mathews, H. S. McDonald,* Bell Telephone Laboratories

A High-Speed Digital-to-Analog Voltage Decoder. *B. A. Antista,* Autonetics-North American Aviation

Optical Information Handling with Thin Magnetic Films. *Leonard Kleinrock,* Massachusetts Institute of Technology

A Drift Compensated Operational D-C Amplifier Employing A Low Level Silicon Transistor Chopper. *F. H. Gerhard, W. Hochwald,* Autonetics-North American Aviation

Radar and Radio Navigation

Radar Interference Problem. *S. O. Newman, K. H. Chase,* Sperry Gyroscope Company, Sperry Rand Corp.

Detection of Radar Signals by Direct Measurement of their Effect on Noise Statistics. *G. I. Cohn, L. C. Peach,* Illinois Institute of Technology

Use of Raydist System for Inertial Autonavigator Flight Test. *H. V. Miller,* Autonetics-North American Aviation

Design Considerations for Doppler Spectrum Simulators. *S. Sherr, S. Beniamin, S. King, P. M. Levy,* General Precision Laboratory, Inc.

Magnetic Amplifiers

Evaluation of 4-10 Kc Amplistat Design Techniques. *D. L. Watrous, J. D. Harnden, Jr.,* General Electric Company

Applications of Saturable Cores in Transistor Power Converters. *R. P. Putkovich, T. M. Corry,* Westinghouse Electric Corporation

Time Interval Generation with Transistor Switches and Magnetic Cores. *R. L. Van Allen,* Magnetics, Inc.

Reversible D-C Shunt Motor Drive Using Magnetic Amplifier and Controlled Rectifiers. *W. R. Seegmiller,* General Electric Company

High-Voltage Magnetically Regulated D-C Supply. *W. J. McDaniel, T. L. Tanner,* Bell Telephone Laboratories

Luncheon

Address: Dr. Simon Ramo, The Ramo-Wooldridge Corp., Los Angeles, Calif.

Afternoon Sessions

Engineering Management

Idea Flow in R and D. *A. H. Rubenstein, R. W. Avery,* Massachusetts Institute of Technology

Organization for Research and Development from the Engineer's Point of View. *F. E. Butterfield,* Sylvania Electric Products, Inc.

Factors Which Lead to Creative R and D Performance. *A. E. Oriel,* Science Research Associates

A Positive Look at the Weapons System Management Concept. *R. B. Leng,* Packard-Bell Electronics Corp.

Industrial Electronics

Gated Amplitude Ratio Indicator. *R. R. Bockemuehl,* General Motors Corp

Ultrasonic Evaluation of Structural Adhesive Bonds. *C. T. Vincent, J. S. Arnold,* Stanford Research Institute

Resistance Distribution Analyzer for Printed Resistors. *J. H. Ott,* Centralab Division of Globe-Union, Inc.

Electronic Surge Testing of D-C Armatures with Null Detection. *H. R. Weed,* Ohio State University

Television

The TASO Television Field Strength Measurement and Analysis Program. *H. T. Head,* A. D. Ring & Association; *Harry Fine,* FCC, Washington, D. C.

Design Considerations in the Second Detector Circuit of Monochrome TV Receivers. *L. J. Mattingly,* Motorola, Inc.

Optimum Source Impedance and Noise Figures of TV Input Tubes with Various Circuits. *Lloyd Matthews,* Zenith Radio Corp.

Automatic Hue and Amplitude Control in Color TV. *Zbigniew Wiencek,* Warwick Manufacturing Corp.

Communications

An Investigation of Signal Amplitude to Bearing Deviation Correlation as a Function of Time in High Frequency Radio Direction Finding. *A. D. Bailey, R. L. Sydnor,* University of Illinois

Performance of a Scatter Link Using Frequency Compression. *M. O. Felix,* Canadian Westinghouse Company

Cumulative Binary Decision-Feedback Systems. *S. S. L. Chang, B. Harris, K. C. Morgan,* New York University

Modification of Pulse Shapes Derived from Fresnel Integral Spectra. *C. E. Cook,* Sperry Gyroscope Company-Sperry Rand Corp.

Sample Contents Lists from USSR Scientific and Engineering Journals

THE FOLLOWING are sample contents lists from some of the leading Soviet scientific and engineering journals, translations of which are being made available by arrangement with the Pergamon Institute, a nonprofit organization.

For a listing and prices of the publications, available on an annual subscription basis, and ordering instructions, see p. 82A of this issue of *Electrical Engineering.*

Elektrosvyaz', No. 4, April 1958

Contents

Samoilov, A. I. Instantaneous correlation conversion.

Khatskelevich, V. A.; Shur, L. M. Compensation of nonlinear distortion by reverse envelope connection in radio-transmitting equipments.

Utkin, G. M. Frequency range stabilization using a combination frequency generator.

Minashin, V. P. On the calculation of coaxial circuits for DMV amplifiers.

Fradin, A. Z.; Olendskii, V. A. On measurement of input asymmetry in radio receivers.

Bogoslovskii, Yu. V. Calculation of grounded grid stages in critical conditions.

Tsetlin, M. L.; Eidus, G. S. Matrix method of synthesizing multicycle relay-contact circuits for communications and control.

Ufel'man, A. F. Use of a potential analog in the calculation of electrical filters.

Gorodetskii, P. G. Calculating the equivalent parameters of nonuniform grounds, taking into account surface effects.

Izakson, B. K. Leveling the frequency response of frequency filters in the pass band.

Zaezdnyi, A. M. The passage of rectangular pulses along infinite lines, the resistance of which varies with frequency.

Demkov, M. G. On the problem of the ideal receiver.

From Foreign Journals

Certificates of Authorship

Foreign Patents

Radiotekhnika, Vol. 13, No. 4, April 1958

Contents

Zaezdnyi, A. M. Fourier series technique as a method of studying linear systems.

Ovseevich, I. A.; Pinsker, M. S. Estimation of some real communication channels.

Klyachkin, L. Z. Capacity of binary pulse-code systems for unequal probabilities of distortion of symbols.

Mikaelyan, A. L.; Koblova, M. M. The use of ferrites to make coaxial valve systems.

Tartakovskii, L. S. General mathematical formulas for the field due to an arbitrarily orientated dipole over a uniform grounded plane.

Agakhanyan, T. M.; Patrikeev, L. N. Determination of the limiting frequency of the current transfer ratio of semiconductor surface triodes.

Tsvetnov, V. V. Phase correlation properties of signals and Gaussian interference in 2-channel phase systems.

Rostovtsev, Yu. G. On the distribution laws of the null and extreme points in Russian speech when strictly limited in amplitude.

Krivitskii, B. Kh. On the passage of pulses through an amplifier with quick-acting automatic amplification control.

Tsukkerman, I. I. On the transfer of co-ordinates of elements of television pictures.

Letter to the Editor

Palshkov, V. V. On the calculation of pulse limiters.

Radiotekhnika I Elektronika, No. 4, 1958

Contents

Aksenov. Scattering of electromagnetic waves from trochidal and sinusoidal surfaces with finite conductivity.
Mathanov. A method of realization of minimum-phase circuit transmission functions by cascaded grounded circuits.
Vitkevitch. Investigation of discontinuities in ionosphere by radio-astronomical methods.
Riskin. The analysis of Tomson's oscillating systems.
Stratonovitch. Synchronization of an oscillator in the presence of interference.
Raevsky et al. Synchronization of an oscillator by a sinusoidal force in the presence of fluctuation noise.
Kuleshov. Band-range properties of some devices with distributed parameters.
Prozorovsky. Method of analysis of distributed amplifiers.
Kornilov. Frequency division in a triple-transit klystron.
Bychkov. Approximate method of induced current determination in resonator magnetrons.
Goldman. Spectral distribution of selenium photocell currents in photodiode regime.
Penin et al. Input impedance of germanium and silicon detectors at centimeter waves.
Malakhov. Impedance fluctuations of semiconductor detectors.
Bunimovitch. Approximate expression for detection probability of a signal with unknown phase at optimum reception.
Fleishman et al. Maximum anthropy of unknown discrete distribution at given first moment.
Kalinin. Perturbance of a plane wave field by irregularities of earth surface.
Kuzmin. Measuring a radiation intensity of sources with small angle dimensions.
Glebovitch et al. Examination of some circuits for the formation of short pulses.
Hokhlov. Locking of molecular oscillator by a small external force.
Vasneva et al. Molecular standard of frequency.
Mirkotan. Device for frequency-diversity reception.
Borodin. Doubling of frequency in backward-wave tube.
Braginsky et al. Selection of higher harmonics of reflex klystron by cavities of a complex form.
Griaznov. Application of thyratron in a fast sweeping circuit.

Letters to the Editor

Bocharov, V. G.; Bass, F. G. Scattering of electromagnetic waves by a statistically irregular surface.

Discussions

Troitsky, V. S. The paper by V. I. Tikhonov and I. N. Amiantov "Influence of slow fluctuations on an oscillator."
Tikhonov, V. I.; Amiantov, I. N. Reply to V. S. Troitsky.

Chronicle

Titov, N. K. The 60th birthday anniversary of I. Kh. Neviazhsky.

AIEE Schenectady Section Contributes to Building Fund

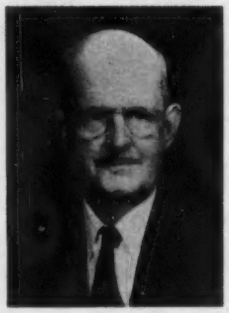
The Schenectady Section of the AIEE has the honor of being the first Section of any of the participating Societies to report subscriptions of $27,000, nearly 10% more than its quota, to the new United Engineering Center. This report came from 75% of the members, 80% of whom subscribed the $27,000. Of the members, 25% are still to be heard from.

The Schenectady Section organized its drive during July, and the results obtained are evidence of the thorough organization that was developed.

Dr. Calvert Awarded Medal in Electrical Engineering Education

The AIEE Medal in Electrical Engineering Education will be presented to Dr. J. F. Calvert (F '45) head of the department of electrical engineering at the University of Pittsburgh, during the Fall General Meeting of the Institute, to be held in Pittsburgh, Pa.

Dr. Calvert has been awarded the medal ". . . in recognition of his distinguished service as a teacher of electrical engineering and as evidence of the high esteem in which his contributions to engineering education are held by his fellow members of the American Institute of Electrical Engineers."



J. F. Calvert

Dr. Calvert was born in Columbia, Mo., on October 14, 1898. After service in the U. S. Infantry during 1916-19, he completed work for a B.S. degree in E.E. at Missouri. Later he received his M.S. degree in E.E. and a Ph.D. in mathematics from the University of Pittsburgh. He was a design and development engineer for 12 years with the Westinghouse Electric Corporation on large a-c machinery, and served part time as a graduate lecturer at the University of Pittsburgh. For 2 years, he was an associate professor at Iowa State College, and for 16 years he was chairman of electrical engineering at Northwestern University, before going to his present position in 1954. His early research and publications were concerned with calorimeter tests on rotating machinery, magnetic fields, iron losses, short-circuit forces, ventilation, insulation, lightning protection, armature windings, and ship propulsion; more recently, publications relate to special-purpose analog computer designs, economic models, loss minimization in utility systems, and special types of open- and closed-loop control systems. He was on loan, 1941-42, to the Naval Ordnance Laboratory for the design of, and to represent that organization on the construction of, the Pacific Magnetic Proving Ground in Pearl Harbor. He conducted research for the Bureau of Aeronautics, 1944-54, on measurements and computations related to aerial warfare. Dr. Calvert is a member of the American Society for Engineering Education, American Association for the Advancement of Science, Institute of Radio Engineers, Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and Sigma Tau. His AIEE Committee services include: Electrical Machinery (1939-47, vice-chairman 1942-46); Student Branches (1946-49, chairman 1948); Air Transportation (1946-47); Membership (1947-48); Edison Medal (1950-55, chairman 1952-53); Professional Division Advisory (1951-52); Washington Award Commission (1952-54); Computing Devices (1953-56); and Fortesque Fellowship Committee (1954-57, chairman 1957). He served as chairman of the AIEE Chicago Section (1945).

Niels Bohr International Gold Medal

It has been announced by The Institution of Danish Civil Engineers that the Niels Bohr International Gold Medal 1958 will be awarded to the famous British scientist, Sir John Cockcroft.

His Majesty the King of Denmark has consented to present the medal personally to Sir John on October 7, 1958.

Call for Technical Papers

The 1959 Electronic Components Conference, sponsored by the AIEE, Institute of Radio Engineers, Electronic Industries Association, and West Coast Electronic Manufacturers Association, is soliciting papers on the subjects of electronic components and materials. A 150- to 200-word abstract, together with title and author's name, should be sent to the Technical Program Chairman: Brig. Gen. E. R. Petzing, AGEP Secretariat, University of Pennsylvania, 200 S. 33rd St., Philadelphia 4, Pa. The deadline for abstracts is October 15, 1958.

The theme of this Conference, to be held at the Benjamin Franklin Hotel in Philadelphia May 6-8, 1959, is "New Concepts for Space Age."

Conference subjects for which papers are requested include: components and their application in space vehicles; microminiaturization and the new component—the micro-module; developments in materials and their application to components; professional and tutorial papers on the mechanism of failure (operation) of components; new techniques for electronic filtering, tuning, and switching; transistors, diodes, and rectifiers; electron tube devices; instrumentation and control devices; survey of improvements in components; new developments in passive components; components for military, industrial, and home appliance applications of the future; and radiation effects.

Corpus Christi Section Reports on Library Project

The Corpus Christi Section of AIEE has completed a project to place *Electrical Engineering* in the library at Texas College of Arts and Industries. These issues

are now complete from January 1, 1926, to the present. They are bound in semi-annual (January to June, July to December) volumes, catalogued and made available to the students and to the engineers of the area. The Section also has a near complete file of AIEE Transactions in the college library.

Work is now in progress to complete a similar file of *Electrical Engineering* in the Del Mar College library. Some 20 years have been completed and the majority are bound. The Del Mar library supply of *Electrical Engineering* is being used as the reference basis for a technical writing course now being made available to pre-engineers.

Mexico Section Installs Officers

The new slate of officers of the AIEE Mexico Section was installed at the June Dinner Meeting of the Section at the American Club in Mexico City.

The outgoing Chairman, Julio Colón, administered the oath of office to the new group of officers who are: Alfonso Fernandez del Busto, chairman; Julio Colón, vice-chairman; G. Solis Payan, secretary; Antonio Baca, treasurer; and the following members of the board of directors: Camilo Argüelles, Jose Ortiz de Rosas, A. W. Gelbke, Fernando Corral, and Boris Antipovich.

During the ceremony, honor certificates from AIEE Headquarters were presented to J. W. Thompson, dean of the Mexico Section, on his completion of 60 years of membership in the Institute and to outgoing Chairman Julio Colón in recognition of his work in behalf of the Institute during the past year.

Chairman Fernandez del Busto outlined his plans for the Section during the coming year emphasizing the establishment of technical round table sessions and the operation of the Section library, which is now quite extensive. His plan was accepted with enthusiasm by the assembly.

After dinner, an interesting film was shown, followed by the drawing for the ladies' door prize, a beautiful portable radio which had been donated by one of the members. There were 70 members and wives present at the meeting.

Steinmetz Memorial Program Telecast in Schenectady, N. Y.

The 30th Steinmetz Memorial Program, sponsored by the Steinmetz Memorial Foundation and the Schenectady Section of the AIEE, was presented May 18, 1958.

This year's lecture, "Man's Satellites: Doorway to Space," was delivered by Dr. J. A. Hynek, associate director of the Smithsonian Astrophysical Observatory, Cambridge, Mass., who is in charge of the IGY Earth Satellite Optical Tracking Program.

In his lecture, which was the first of the Steinmetz Programs to be telecast, Dr. Hynek pointed out that 'While it is important to demonstrate the prowess of the human race by launching a satellite, if for no more than as a keystone to cap the struggle for understanding that began its modern phase with those giants Newton spoke of—Copernicus, Galileo, Brahe, Kepler—it would be pointless to continue such celebrations."

"Intelligent planning and intelligent use," he said, "are needed to keep the space age from sinking abortively to the level of just new tools and a new sphere for warfare.

"Satellites," he continued, "must be used solely as instruments to enhance the struggle for greater understanding and mastery of man's environment. They can become the seven-league boots to conquer a new dimension."

Dr. Hynek discussed, in some detail, the most significant problems of monitoring and tracking satellites; outlined the tracking of lunar vehicles, and vehicles to the planets; discussed manned versus instrumental satellites and space vehicles; and outlined, as to scope and possibility, the astronomer's dream—an observatory in space.

THE NEW CHAIRMAN of the AIEE Mexico Section being introduced to the audience by the outgoing chairman, at a dinner in the American Club of Mexico City. Members shown (*left to right*) are: Camilo Argüelles, Boris Antipovich, R. Heres Ruiz, I. Ramirez Balderas, F. R. Corral, J. Mireles Malpica, Chairman Alfonso Fernandez del Busto, Dean J. W. Thompson, and past Chairman Julio Colón.

DR. J. A. HYNEK (*second from right*), speaker for the Steinmetz Memorial Program, demonstates a point during his lecture, "Man's Satellites: Doorway to Space," which was telecast from Station WRGB, Schenectady, N. Y. Also present are: J. L. Dutcher (*left*), general chairman of the Steinmetz Memorial Lecture Committee; Prof. H. H. Bibber (*second from left*), chairman, AIEE Schenectady Section; and L. T. Jester (*right*), Section Program Committee. The program was presented May 18, 1958.

AIEE Philadelphia Section

OFFICERS, Executive Committee members, representatives, and committee chairmen of the Philadelphia Section for 1958-59, present at the first Executive Committee Meeting, June 9, 1958, are: (*first row, left to right*) R. T. Ferris, manager; B. B. Young, manager; T. H. Story, manager; W. S. Osborne, manager; W. C. Bloomquist, manager; W. O. Mascaro, treasurer; G. B. Schleicher, chairman; M. L. Stoughton, vice-chairman; R. L. Halberstadt, secretary; F. C. Powell, manager; T. E. Stieber, senior past chairman; (*middle row, left to right*) D. R. Boone, manager; C. R. Hansen, chairman, Communications Technical Division; M. Lichstein, public relations; A. D. Spillman, electric heating; G. R. Tucker, transfers; A. E. Carlson, attendance; G. E. Bodenstein, history; E. F. Jones, finance; H. W. Sommer, secondary schools; E. J. Brown, chairman, Atlantic City Division; (*back row, left to right*) B. S. Weinfeld, publicity; G. V. Jacoby, legislation; I. C. Lomis, inspection trips; B. H. Zacherle, junior past chairman; R. Mayer, recording; S. Charp, chairman, Science, Electronics, and Instrumentation Technical Division; J. C. Walter, registration; E. R. Burgin, chairman, Power and Applications Technical Division; J. L. Weare, membership; T. H. MacCauley, radio; G. Balderston, papers and meetings.

Machine Tool Conference To Be Held in Hartford, Conn.

The 10th National Machine Tool Conference sponsored by the AIEE will be held at the Statler Hilton Hotel in Hartford, Conn., October 13-15, 1958.

This annual Conference, widely attended by machine tool manufacturers, suppliers of electrical equipment, and users of machine tool equipment throughout the country, provides a forum for those wishing to stay abreast of the rapidly changing developments and needs of the machine tool industry.

This year's program presents a balanced coverage of the industry's progress in the fields of tooling, gaging, machine control, computers, safety, precision positioning and machine design. Presentations will be made by leading engineers in the industry discussing operating experience with modern machine tool equipment. Plant tours through several major Connecticut industries also have been arranged.

The Governor of the State of Connecticut, A. A. Ribicoff, will address the Conference during one of the luncheon meetings.

Last year, this Conference, held in Milwaukee, Wis., drew over 800 registrants. This year, attendance of over 1,000 is anticipated.

Registration fee for AIEE members is $3, for nonmembers $5. Advance registrations may be made with W. P. Carpenter, chairman of the Registration committee, c/o Superior Electric Company, 83 Laurel St., Bristol, Conn.

Other members of the Arrangements Committee are: E. E. Kirkham, general chairman; R. H. Porterfield, chairman, Financial Committee; G. E. Akin, chairman, Meeting Facilities Committee; A. E. LaPlant, chairman, Accommodations and Transportation Committee; J. L. Dutcher, chairman, Program Committee; W. S. Randall, chairman, Publicity Committee; W. J. Blaiklock, chairman, Plant Visits and Transportation Committee; and K. Wilson, chairman, Luncheon and Banquet Committee.

The tentative technical program for the Conference follows.

Monday, October 13

8:00 a.m. Registration

9:00 a.m. Plant Visits

Pratt & Whitney Aircraft Corp., East Hartford, Conn.

Arrow Hart & Hegeman, West Hartford, Conn.

2:00 p.m. Session I

Welcome: E. E. Kirkham

Keynote Talk: Speaker to be announced

CP58-5018 Tooling for Guided Missiles and Rockets. *C. L. Phillips,* The Martin Company

CP58-5019 A Year of Operating Experience with Numerical Control. *W. Beeby,* Boeing

CP58-5020 Operating Experience with Relays and Limit Switches. Pontiac

CP58-5021 Operating Experience with Static Switching. *M. R. Pardell,* A. C. Sparkplug

7:30 p.m. Banquet

Speaker: W. H. Upson, "You Don't *Have* To Be Crazy—Or What It Takes To Be a Salesman"

Tuesday, October 14

9:00 a.m. Technical Session II

CP58-5022 Tubes Vs. Transistors in Machine Control. *H. Grossman,* Concord Controls

CP58-5023 Fundamentals of Computers. *William McClelland,* International Business Machines Corporation

CP58-5024 Photoelectric Line Follower. Westinghouse Electric Corporation

CP58-5025 Improved Safety in Stamping Presses. *Roland Russo,* Clark Controller Co.

12:30 p.m. Luncheon

Speaker: A. A. Ribicoff, Governor of the State of Connecticut.

2:00 p.m. Technical Session III

CP58-5026 Precise Linear Positioning of Machine Tools. *Charles Witham,* Cutler Hammer

CP58-5027 A New Concept in Automatic Machines. *W. Brainard,* Kearney and Trecker

CP58-5028 Practical Problems in Applying Gages to Machines. *Greig Butterworth,* Cincinnati Milling Machine Co.

Panel: "Designing Machines for Servo Drives"

Wednesday, October 15

9:00 a.m. Technical Session IV

CP58-5029 D-C Water Cooled Spindle Motor and Control. *Al Bowman,* Allis-Chalmers Manufacturing Company

"New Electric Products for Machine Tools." A series of 5 minute talks each describing a device which is something basically new, not just a redesign.

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33 West 39th Street,
New York 18, N.Y.

CP58-5030 The Controlled Rectifier and its Application. *W. D. Cockrell,* General Electric Company

CP58-5031 A Power Servo for Automatic Machines. *J. A. Hudak,* Reliance Electric

1:00 p.m. Field Trips

Pratt & Whitney Co., Inc., West Hartford, Conn.

New England Machine & Tool Co., Berlin, Conn.

New Britain Machine Co., New Britain, Conn.

New Departure Division, General Motors Corp., Bristol, Conn.

Cincinnati Supports Building Fund Campaign

Local Sections of the Founder Societies in Cincinnati, Ohio, representing AIEE, American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), and American Institute of Chemical Engineers (AIChE), have joined forces in a combined effort to canvass the total of about 1,500 individual members in the Cincinnati area in support of Joint Member–Gifts Campaign for the United Engineering Center Building Fund.

A Sponsoring Committee comprised of representative leaders of the engineering profession in this industrial community has been organized under the chairmanship of E. S. Fields, president of The Cincinnati Gas & Electric Company, to give direction and general support to the campaign effort.

Local Section Committees are coordinating their efforts in solicitation work. Four divisions have been formed to cover industry groups and geographical areas in order to reach personally every Founder Society member in the Cincinnati area.

Pulp and Paper Industry Conference

The Pulp and Paper Industry Subcommittee of the Institute has announced that the 5th Annual Conference on Electrical Engineering as applied to the Pulp and Paper Industry will be held June 18-19, 1959, at the University of Maine, Orono.

As in the past, this Conference will be sponsored by the Subcommittee, the University of Maine, and the local Section of AIEE.

Dr. M. J. Kelly To Receive John Fritz Medal for 1959

Dr. M. J. Kelly (F '31), president of Bell Telephone Laboratories, will be the 1959 recipient of the John Fritz Medal, it was announced by the John Fritz Medal Board of Award representing four major national engineering societies.

Cited for ". . . his achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology," Dr. Kelly will receive the award at ceremonies to be scheduled by the AIEE.

OFFICERS of Cincinnati Sections of Founder Societies working on Cincinnati area fund drive for the United Engineering Center are: (*left to right*) K. H. Pettengill, AIChE; C. Wandmacher, ASCE; R. Nelsen, ASME; W. G. Hamlin, ASCE; H. S. Progler, AIEE; H. J. Peddicord, AIChE; L. L. Bosch, ASME; and E. S. Fields, chairman, Sponsoring Committee.

The John Fritz Medal is sponsored jointly by the AIEE, the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, and The American Society of Mechanical Engineers. Presented not more than once in any year for "scientific or industrial achievement" in any field of pure or applied science, it was established in 1902 as a memorial to the great engineer and steel maker whose name it bears.

The roster of John Fritz medalists includes the names of some of the world's most illustrious engineers and scientists: Westinghouse, Alexander Graham Bell, Edison, General Goethals, Orville Wright, Marconi, Sperry, Hoover, Pupin, Kettering, and others. The award for 1959 goes to a man who has had a highly active and distinguished career.

Dr. Kelly joined the Research Division of the engineering department of Western Electric, predecessor of Bell Laboratories, in 1918. Assignments as director of vacuum tube development and as development director of transmission instruments and electronics preceded his appointment in 1936 as director of research. He became executive vice-president in 1944 and, in the spring of 1951, president of the Laboratories.

M. J. Kelly

Dr. Kelly has had wide experience not only in the research and development of telephone equipment, but also in projects for the Armed Forces. In the course of World War II, the Laboratories converted almost completely to military research and development programs, all of which were under Dr. Kelly's guidance. In recognition of his World War II contributions, he received the Presidential Certificate of Merit.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. Members may receive one subscription to any *one* of the bimonthlies for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions will be at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Vice-Presidents Present Fellow Diploma

I. T. MONSETH (*left*), incoming vice-president of AIEE District No. 7, and N. F. Rode (*right*), outgoing vice-president of the District, present Fellow diploma to P. H. Robinson (center), executive vice-president of the Houston Light and Power Company, during a social meeting of the AIEE Houston Section.

Richard Pervin Photography

Since the war, he has held many public service assignments in Washington, D. C., particularly with the Atomic Energy Commission, the Department of Commerce, and the Department of Defense. He is a member-at-large of the Defense Science Board. Among his many honors are the Air Force Exceptional Service Award and the 1953 Trophy of the Air Force Association, awarded ". . . for distinguished service to air power in the field of science."

Dr. Kelly is also active in the field of education. He is a life member of the Massachusetts Institute of Technology Corporation and a member of its Executive Committee; and a trustee of Stevens Institute of Technology; and serves on advisory committees at Massachusetts Institute of Technolgy, Princeton, New York University, Case Institute of Technology, Columbia University, and the New York City Board of Education.

He is also a trustee of the Alfred P. Sloan Foundation and a trustee and member of the corporation of Atoms for Peace Awards.

One of the most recent achievements in the interests of the engineering profession has been Dr. Kelly's chairmanship of the industry campaign to raise funds for the new $10 million United Engineering Center, which will be the national headquarters for engineering societies whose membership totals over a quarter of a million engineers.

A graduate of the Missouri School of Mines and Metallurgy, Dr. Kelly received the Ph.D. from the University of Chicago in 1918. He has been awarded seven honorary doctorates by American and European universities in recognition of his distinguished contributions to science and research.

He is a member of the National Academy of Sciences and the American Philosophical Society, a foreign member of the Swedish Royal Academy of Sciences, and is associated with many other scientific and professional societies.

The John Fritz Medal Board of Award consists of 16 past presidents of the sponsoring societies, four from each. Administration of the John Fritz Medal program is a function of United Engineering Trustees, Inc.

AIEE FELLOWS ELECTED

Board of Directors Meeting, June 27, 1958

Emerson A. Armstrong (AM '13, M '32), consulting engineer, Electromotive Division, General Motors Corporation, La-Grange, Ill., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to diversified electrical applications in industrial processes." Mr. Armstrong was born in Toledo, Ohio, on January 20, 1890. He received his B.S. degree in E.E. from Michigan State College in 1911 and a professional E.E. degree in 1922. For five years after graduation, he was with Continental Utilities Co., Lansing, Mich., as general design and construction engineer and as resident superintendent of systems serving several towns in Indiana. During World War I, he was associate professor of physics at Michigan State after which he spent some time in maintenance and construction departments of industrial plants in Detroit, Mich. In 1921, he joined the Public Service Company of Northern Illinois. He became power engineer and manager of industrial sales in 1923. When that company was taken over by Commonwealth Edison Company in 1952, he continued in the same capacity for the combined companies. Since his retirement from Commonwealth Edison Company in 1954, he has been consultant to the Electromotive Division of General Motors on the design and application of automatic diesel generating units for utilities. Mr. Armstrong has contributed to various electrical magazines and to the "Standard Handbook for Electrical Engineers." He is a registered professional engineer in Illinois, a member of Tau Beta Pi, Western Society of Engineers (member-for-life), and was one of the organizers of both the Great Lakes Power Club and the Petroleum Electric Power Association. He was the first chairman of the AIEE Chicago Section Industrial Group. He has served on the AIEE General Power Applications Committee (1930-38) and the Industrial Power Applications Committee (1938-42.)

William Philip Carpenter (AM '36, M '42), secretary and chief engineer, The Superior Electric Company, Bristol, Conn., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to techniques of controlling electric illumination." Mr. Carpenter was born in Poughkeepsie, N.Y., on October 17, 1913. He received the E.E. degree from Rensselaer Polytechnic Institute (RPI) in 1935, and took extension courses at Indiana University, Hillyer College, and Indiana Technical College. After graduation in 1935, he was employed by the General Electric Company (GE) in their test department for graduate engineers, Schenectady, N.Y. He transferred to the specialty transformer department, Fort Wayne, Ind., in 1936. During this same period, he also taught elementary radio in the Fort Wayne School system. In 1939, he left GE to work for the United States Government on the Panama Canal, at Pedro Miguel, Canal Zone. In 1942, he became associated with The Superior Electric Company of which he is presently secretary and chief engineer. Mr. Carpenter's AIEE activities started when he served as secretary of the Student Branch at RPI. While in the Connecticut Section, he has been a member and chairman of the Industrial Electronics Committee for three years, the Nominating Committee and the Committee for Transfers and Advancement. Mr. Carpenter is a registered professional engineer in the States of Indiana and Connecticut. He serves as secretary of the Connecticut Section of the Illuminating Engineering Society (IES) and a member of the IES national Light Sources Committee. He is the author of several technical articles and holds patents in the field of lighting control and electromagnetic devices.

Leo Dolkart (M '46), electrical engineer, A. S. Schulman Electric Co., Electrical Contracting Engineers, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of diversified industrial distribution and lighting systems." Mr. Dolkart was born in Caucasia, on September 14, 1881, and came to the United States on July 4, 1893. He received his B.S. degree in E.E. from the University of Illinois in 1903. Mr. Dolkart had charge of installing the first automatic telephone exchange in

Hinchliffe Studio

E. A. Armstrong

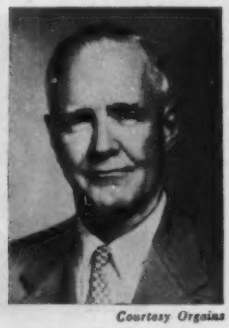
W. P. Carpenter

Leo Dolkart

Chicago. During his career he has served as telephone engineer with the Automatic Electric Co., later with the Western Electric Co.; chief engineer, Tri-City Electric Co.; and owner, Moline Electric Co. In 1930, he became chief electrical engineer with Albert Kahn, Inc., at Moscow, USSR, in connection with the First Five Year Plan of Industrialization of the USSR. During World War II, he was chief electrical engineer in charge of design and construction for the U.S. Navy project at Newport, R.I. He also served as chief engineer of the Leonard Construction Co.; consulting engineer for Cementos Portland del Bajio, S.A., at Leon, Gto., Mexico; electrical engineer and purchasing agent, Commercial Light Co.; and chief engineer, Latin American Export Service. Mr. Dolkart is a charter and emeritus member of the Illuminating Engineering Society; charter military engineer member, Society of American Military Engineers; and a member of the Illinois Engineering Council, Illinois Society of Professional Engineers, Society of Technical Writers and Editors, Western Society of Engineers, and other organizations. He has received the G. W. Fleming Safety Trophy, Military Engineers Award, and the First Award of Merit and Gold Anniversary Pin of the Illuminating Engineering Society. He is a registered professional engineer in the States of Illinois and Rhode Island. Mr. Dolkart has served on the AIEE Industrial Power Systems Committee. (1949-55, 1956-58).

Wendell Charles Fowler (AM '30, M '36), district manager, Southwest District, Sangamo Electric Co., Forth Worth, Tex., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to instrumentation in the field of power." Mr. Fowler was born on January 31, 1900, in Emporia, Kans. After attending Phillips Exeter Academy, he enlisted in the U. S. Navy in 1918 and entered the U. S. Naval Academy, Annapolis, Md., in 1919, graduating in 1923 with a B.S. degree. From 1923 to 1924, he served as junior fire control officer (Ensign, USN) aboard the *USS Colorado*. Mr. Fowler joined the Sangamo Electric Company, Springfield, Ill., in 1927. He transferred to Texas to become manager of the Southwest District for Sangamo in April 1928. Mr. Fowler is a member of the Engineers Club of Dallas, and the Dallas Electric Club. He has served on various committees of the AIEE San Antonio Section and North Texas Section, and in 1947-48, served as chairman of the latter Section. He is a registered professional engineer in the State of Texas. Mr. Fowler is recognized throughout the southwest as an authority on the engineering features of instrumentation, having appeared as speaker at regularly scheduled meetings of AIEE Sections and Subsections. He has also conducted similar meetings and been principle speaker at Student Branches in District No. 7. For the past 20 years, he has been actively identified with the meterman's short course held at Texas A&M College each Spring. In 1944, he organized the Fort Worth Electronics Club and served as its first president. He has served on the AIEE Membership Committee (1939-40, 1944-48, 1956-58) and Student Branches Committee (1953-56).

Owen Wilson Hurd (AM '38, M '46), managing director, Washington Public Supply System, Kennewick, Wash., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design, operation, and management of large electric power systems." Mr. Hurd was born in Eugene, Oreg., on January 31, 1903. He received the B.S. degree in E.E. from Oregon State College in 1926. He began his career in the electric utility field as a meterman with the Northwestern Electric Company in Portland, Oreg., in 1926. He was with the same company until 1939, in various positions in the testing and communications department and as assistant electrical engineer. In 1941, he joined the Bonneville Power Administration (BPA) as electrical engineer in the Operation and Maintenance Section. He was appointed BPA district engineer in Spokane, Wash., in 1943 and district manager in 1947. He accepted the position as manager and chief engineer of the Benton County Public Utility District at Kennewick in 1948. In October 1957, he became managing director of the newly formed Washington Public Power Supply System, a group of 17 Washington Public Utility Districts joined together as a single municipal corporation for the purpose of building hydroelectric and thermal electric plants and transmission facilities to meet member utility future power requirements. Mr. Hurd served as chairman of the AIEE Spokane Section, 1947-48, and as general chairman of the Pacific General Meeting held in Pasco, Wash., in 1957. He has served on the AIEE Domestic and Commercial Applications Committee (1953-58). He has been president of the Northwest Public Power Association and of the American Public Power Association. He served as special consultant to the Defense Electric Power Administration during the regional "brown-out" in 1951. He is a registered professional engineer in the States of Oregon and Washington.



Courtesy Orgains

W. C. Fowler

Courtesy K. Dobibas

O. W. Hurd

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

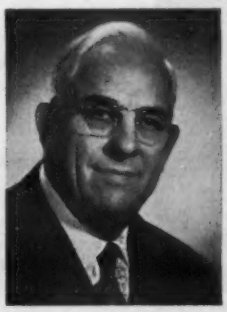
Stanley Charles Killian (AM '42, M '46), assistant general manager and chief engineer, Delta-Star Electric Division, H. K. Porter Company, Inc., Chicago, Ill., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of high-voltage bus and switching apparatus." Mr. Killian was born in Chicago on July 4, 1906. He received the B.S. degree from the University of Michigan in 1934, and engaged in postgraduate work at Northwestern University. He joined Delta-Star in 1934, becoming research and development engineer in 1941, chief engineer in 1944, and assistant general manager in 1954. Mr. Killian has been instrumental in the pioneering of braidless-type outdoor disconnecting switches, contact construction, in the study of circulating currents in high capacity bus enclosures, and in the design of new bus configurations. He is a frequent contributor to AIEE and electrical magazines on switchgear, contact, and bus design. In 1951, he won the AIEE Great Lakes District Paper Award for a paper entitled "Induced Currents in High Capacity Bus Enclosures." He holds many patents on high voltage switches, contacts, interrupters and enclosed buses including the telescopic, isolated-phase bus. Mr. Killian is a member of Tau Beta Pi, Eta Kappa Nu, American Society for Testing Materials, and Western Society of Engineers. He is a member of ASA (American Standards Association) C-37, Power Switchgear, and many NEMA (National Electrical Manufacturers Association) Committees. He served on the AIEE Substations Committee (1948-58), was chairman of the Transmission Substation Subcommittee (1955-57), and chairman of the Working Group on Minimum Electrical Clearances. Mr. Killian was a member of the United States delegation to the 1958 International Electrotechnical Congress in Stockholm, Sweden.

Everett Paul Larsh (M '44), president, Daytrol Corporation, Dayton, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for inventions and administration in the field of electrical apparatus." Mr. Larsh was born in Richmond, Ind., on June 16, 1886. He began his career in the electrical industry in 1902 at the age of 16 when he was employed by the Remy Brothers who operated a small electric shop manufacturing a small bipolar d-c generator used for make-and-break ignition systems of gas engines, with five factory employees and two office employees. This partnership later became the Remy Electric Company, now a division of the General Motors Corporation. Mr. Larsh served as an apprentice assembling armature cores, winding armatures and fields, building commutators and testing the small bipolar generators. He enrolled with the International Correspondence School for the study of electrical engineering, completing the course while serving in the U.S. Navy as a wireless operator from 1906 through 1910. In 1915, he organized the Burnett-Larsh Company for the manufacture of domestic electric water systems. He organized The Master Electric Company in 1920 for the manufacture of a line of electric motors, serving as president and general manager until 1936, and as president until 1942. He continued as chairman of the board of directors until The Master Electric Company was dissolved through its merger with the Reliance Electric and Engineering Company, and is presently serving on the board of directors of the parent company. Since 1955, he has been active as president of the Daytrol Corporation, Dayton, Ohio. Mr. Larsh holds numerous U. S. patents. He is a member of the Dayton Engineers Club.

Walter Guy Roman (M '42), manager, Advanced Development Group, Bettis Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development of nuclear reactors for naval and land power." Mr. Roman was born in Aspen, Colo., on October 31, 1905. He received his B.S. degree in E.E. from the University of Colorado in 1928. Upon graduation, he became a tester in the industrial motor department at Westinghouse. The following year he joined the staff of Dr. C. I. Fortescue, consulting transmission engineer, as one of a number of field men making lightning and traveling wave studies on the transmission lines of the Public Service Electric and Gas Company and on substations and underground cable systems of the Detroit Edison Company. This work was followed in 1930 by studies of the distribution of impulse voltage in transformers windings at the Sharon Transformer Works, and measurements of impulse characteristics of the insulators, lightning arresters, and transformers at Trafford High Voltage Laboratory. In March 1932, he was placed in charge of the Impulse Laboratory in East Pittsburgh. After a short assignment on mercury-arc rectifier design, he returned to the lightning protection field in 1935 as a design engineer in the lightning arrester section. In 1941, he was appointed section manager of the switch and fuse section. During World War II, Westinghouse participated in the design, development, and manufacture of the "Calutron" electromagnetic isotope separators for the Manhattan Project. In 1942, he was assigned to the Manhattan Project, first as manager of the design section, and later as manager of the Westinghouse Development Group at the University of California Radiation Laboratory. At the end of World War II, he transferred to the control engineering department as manager of the electronic control section. In 1951, he joined the then new Atomic Power Division as an advisory engineer and has been associated with the Atomic Power Division at Bettis since that date. In this assignment, he has assisted in the development and design of control rod drive mechanisms, control systems, reactor core, and complete reactor power plants. Mr. Roman is a member of the American Nuclear Society, New York Acadamy of Sciences, Engineering Society of Western Pennsylvania, Eta Kappa Nu, and Sigma Tau.

Paul Emerson Shaad (AM '34, M '46), assistant general manager and chief engineer, Sacramento Municipal Utility District, Sacramento, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in reorganizing and planning an electric power district." Mr. Shaad was born in Lawrence, Kans., on October 6, 1911. He received the B.S. degree in E.E. from Kansas University in 1933. After graduation, he was employed by the General Electric Company until 1940. Following the Test Course, he was engaged in design and application work at Schenectady, N. Y., and later at San Francisco, Calif. From 1940 to 1945, he was employed by The Hawaiian Electric Co., Ltd., Honolulu, T.H., concerned with generation and power system design. In 1946, he became chief electrical engineer and later assistant general manager and chief engineer of Sacramento Municipal Utility District, being principally concerned with engineering for the integration and load expansion of a large municipal electric utility. In his present position, Mr. Shaad has the responsibility for

S. C. Killian



E. P. Larsh

W. G. Roman

P. E. Shaad

J. W. Seaman

L. R. Sellers

R. E. Condit Studio

G. J. Taylor

E. M. Williams

directing the planning and design of a hydroelectric development on the Upper American River. This project consists of 10 dams, 8 tunnels, and 4 powerhouses with a capacity of 250 to 300 mw. Mr. Shaad is a member of the National Society of Professional Engineers, Tau Beta Pi, Sigma Tau, and International Conference on Large Electric Systems. He is a past chairman of the Sacramento Section of the Institute, 1956-57, and is serving on the AIEE Professional Conduct Committee (1957-59).

Joseph Winfield Seaman (M '48), general manager, power transformer department, General Electric Company (GE), Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and manufacture of power circuit breakers." Mr. Seaman was born in Osceola, Ind., on May 14, 1905. He graduated from Antioch College in 1929 with the B.S. degree. Mr. Seaman joined GE in July 1929, and, after completing the Test Program, served as head of Switchgear Test from 1930 to 1932. For the next 10 years, from 1932 to 1942, he was in charge of engineering for the Air Circuit Breaker Division in Philadelphia, Pa., and from 1942 to 1946, was managing engineer for the same component before being named managing engineer for the Power Circuit Breaker Division. From 1947 to 1948, he held the position of assistant works manager of the Philadelphia Works, and from 1948 to 1951, his position was manager—manufacturing of the Philadelphia Works. In September 1951, he was named assistant general manager of the GE Locke Department, Baltimore, Md., and one month later became general manager of Locke. He was appointed to his present position, general manager, Power Transformer Department, Pittsfield, Mass., in December 1954. Mr. Seaman is the author of several technical papers and has been granted 17 patents. He is a registered professional engineer in the State of Pennsylvania. During the Spring of 1949, he attended the Harvard Advanced Management Program. He is serving as president of the Chamber of Commerce, Pittsfield, Mass., for the year 1958.

Lester Ralph Sellers (AM '28, M '44), engineer in charge of electrical specifications and procurement, Tennessee Valley Authority (TVA), Knoxville, Tenn., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to coordination of desgin of large hydroelectric and steam plants." Mr. Sellers was born in Galt, Kans., on March 1, 1900. He received a bachelor's degree in M.E. from Kansas State College in 1924 and completed electrical engineering courses at the University of Tennessee in 1940. Upon graduation in 1924, he joined the General Electric Company, Schenectady, N. Y., where he was employed as a test engineer and later in the central station engineering department. In 1926, he entered the employ of the Philadelphia Electric Company as electrical engineer in their Station Engineering Section. Assignments in this section included hydro, steam plant, and substation design, equipment specification, also system development investigations including 220-kv interconnections. In 1929, he was employed as electrical engineer in the plant engineering department of the Western Electric Company, Chicago, Ill. For over 21 years, Mr. Sellers has been employed in the Design Division of the TVA at Knoxville. This division prepared all the designs for TVA hydro- and steam-generating stations. Since 1949, he has been in charge of a group of electrical engineers responsible for electrical equipment specification, engineering administration of contracts, and coordination of equipment with essential features of station design. Mr. Sellers is author or coauthor of several technical papers covering such diverse subjects as generator neutral grounding, hydro thrust bearing performance, relaying of steam plant auxiliaries, and in January 1956 he presented a paper "Pump-Turbine Unit 2 Addition at TVA Hiwassee Hydro Plant" at the AIEE Winter General Meeting. He has served on the AIEE Hydroelectric Systems Subcommittee.

George J. Taylor (M '44), vice-president in charge of Eastern Operations, Day-Brite Lighting, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the application of electrical lighting to industry." Mr. Taylor was born in Chicago, Ill., on May 13, 1903. He graduated from Armour Institute of Technology in 1925 with a B.S. degree in E.E. and received the M.S. degree in E.E. from Massachusetts Institute of Technology (MIT) in 1926. He returned to Armour to receive his E.E. degree in 1933. He was a member of Eta Kappa Nu. Upon graduation from MIT, he accepted a position as design engineer with G & W Electric Specialty Company in Chicago, Ill., where he was responsible for the complete standardization of low- and high-voltage distribution equipment. In 1933, he moved to Hoboken, N. J., as commercial engineer for the General Electric (GE) Vapor Lamp Co. During this time, he was in charge of research on all new products which included the development of the first industrial luminaire using a rectified fluorescent lamp and the first 400-watt "high intensity" mercury lamp and luminaire. In 1939, he was transferred to the GE Lamp Division in Cleveland, Ohio, as head of the engineering department for industrial lighting. As the start of World War II, he was a consultant for GE on the large industrial lighting program for war plants. He continued this work in the New York area after his transfer in 1942, pioneering the Group Replacement Plan for efficient use of lamps and luminaires in large industrial plants. He left GE in 1945 and spent two years as a consulting illumination engineer applying illumination for specific application related to the scientific solution of involved seeing tasks. In 1947, he joined Day-Brite Lighting, Inc., and is presently in charge of all technical and sales operations relating to illuminating engineering. He is the author of many technical papers on the subject of illumination. Mr. Taylor is president-elect of the Illuminating Engineering Society (IES). He is also a member of the National Society of Professional Engineers and a corporate member of IES in England.

Everard Mott Williams (AM '40, M '47), professor and head of the electrical engineering department, Carnegie Institute of Technology, Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the theory of communication and the development of electric spark machine tools." Dr. Williams was born in New Haven, Conn., on February 2, 1915. He attended Yale University where he received the B.E. degree, with high honors, in 1936 and the Ph.D. degree in 1939, both in electrical engineering. Dr. Williams was employed as a test engineer at the General Electric Company in 1937; as instructor in electrical engineering at the Pennsylvania State College from 1939 to 1942; and as branch (chief) engineer of the Development Branch of the Special Projects

Laboratory, Radio and Radar Subdivision, U.S. Army Air Force, Wright Field, from 1942 to 1945. Since 1945, he has been with Carnegie Institute of Technology where he is now professor and head of the department of electrical engineering. Dr. Williams has served as consultant to a number of agencies in the U.S. Department of Defense and is currently a member of the Scientific Advisory Committee of the Diamond Ordnance Fuze Laboratories, U.S. Army Ordnance Corps. He holds numerous patents on devices for electronics, radar, guided missiles, radio countermeasures, and electric-spark machine tools. He is the author of a number of scientific papers and co-author of the text "Transmission Circuits." Dr. Williams held a Charles A. Coffin Fellowship and the Yale Engineering Association Scholarship for graduate work at Yale University. He received the President's Certificate of Merit for Outstanding Civilian Service in World War II, the 1946 Eta Kappa Nu Award, and the 1957 Pittsburgh Junior Chamber of Commerce Award as "Man of the Year in Engineering." He is a fellow of the Institute of Radio Engineers and a member of the American Society for Engineering Education. Dr. Williams has served on the AIEE Education Committee (1954-58), Fortescue Fellowship Committee (1958-61), Petroleum Industry Committee (1957-58).

AIEE PERSONALITIES

S. S. Attwood (AM '21, F '43), acting dean of the College of Engineering, University of Michigan, Ann Arbor, has been appointed dean of the College. Dean Attwood has been associated with the University of Michigan as a student and as a teacher since 1914. Born in Cleveland, Ohio, on May 29, 1897, he received a B.S. degree in M.E. in 1918 and an M.S. degree in E.E. in 1923. After graduation in 1918, he served as an assistant engineering officer aboard *USS Kittery* and *USS Munrio* until 1919. Dean Attwood was an instructor in electrical engineering from 1920 to 1925, an assistant professor from 1925 to 1933, an associate professor from 1933 to 1937, and since then has held the rank of professor. He has been chairman of the department of electrical engineering since 1953 and has also been acting dean since July 1957. During World War II, Dean Attwood was a member of the U.S. Propagation Mission to England and also was director of the Wave Propagation Group of the Office of Scientific Research and Development with headquarters at Columbia University. He is a member of the American Society for Engineering Education, Engineering Society of Detroit, a senior member of the Institute of Radio Engineers, a fellow of the United States National Committee of the International Scientific Radio Union, and a registered professional engineer in the State of Michigan. Dean Attwood has served on the following AIEE Committees: Electrophysics (1933-42), Basic Sciences (1954-56), Student Branches (1939-41), Edison Medal (1953-58), Education (1954-58), and Membership (1954-56).

H. T. Friis (AM '20, F '41, Member for Life), consulting engineer, Rumson, N. J., has been named recipient of The Franklin Institute's Stuart Ballantine Medal. Dr. Friis, formerly director of research in high frequency and electronics for Bell Telephone Laboratories, is being honored for ". . . his many important contributions to the science of radio-communications during a lifetime of consistently productive research in this field, through which this science has been so notably advanced." Dr. Friis has received four awards for his scientific contributions: Morris Liebmann Memorial Prize of the Institute of Radio Engineers (IRE) in 1939; the Danish decoration, "Knight of the Order of Danneborg," presented by King Frederick IX in 1954; the Valdemar Poulsen Gold Medal presented by the Danish Academy of Technical Sciences in 1954; and the 1955 Medal of Honor of the IRE.

Bartow Van Ness, Jr. (AM '23, F '47), of the Pennsylvania Power & Light Company, Allentown, Pa., has been named chief electrical engineer of the company. Born in Omaha, Nebr., Mr. Van Ness received a bachelor's degree in engineering from Johns Hopkins University and a master's degree in E. E. from Massachusetts Institute of Technology. In 1922, he joined Pennsylvania Water and Power Company which later merged with Pennsylvania Power & Light Company. Mr. Van Ness has served on the AIEE Electrical Machinery Committee (1938-46), Special Committee on Collective Bargaining and Related Matters (1945-48), and Board of Examiners (1950-58).

R. M. Combes (M '54), chief engineer, missile product development, Bendix-Pacific Division of Bendix Aviation Corporation, has been appointed to head engineering and sales activities for the Bendix-Decca radio navigation system for aircraft and ocean vessels.

A. J. Cooper (AM '24, M '50), has retired from the Allis-Chalmers Manufacturing Company after 49 years of service. Mr. Cooper joined Allis-Chalmers in 1909. He was appointed New York district manager in 1945 and Empire Region manager in 1947. Mr. Cooper was active in the affairs of the Institute, serving for two years as chairman of the Winter General Meeting.

W. C. Fisher (M '56), sales manager, Lenkurt Electric Company, has been promoted to marketing manager in the Commercial Products Division of the company.

K. J. Kelly (AM '51), branch manager in Buffalo, N. Y., for the I-T-E Circuit Breaker Company, has been appointed district manager of the Buffalo area.

Marvin Lee (AM '35, M '41), executive vice-president of the Burndy Corporation, Norwalk, Conn., has been elected a member of the board of trustees of the Polytechnic Institute of Brooklyn. Mr. Lee is a member of the American Ordnance Association, the History of Science Society, the Marine Historical Association, and Tau Beta Pi.

C. H. Leet (AM '40, M '55), assistant sales manager, Chicago branch, Exide Industrial Division, The Electric Storage Battery Company, has been named to head Exide's program for national marketing of Electric Products Company battery-charging equipment.

F. M. Ogden (AM '51), marketing manager of the miniature lamp department, Westinghouse Electric Corporation, has been named manager of the Westinghouse photo-miniature lamp department. The photo lamp and the miniature lamp departments were recently combined into one.

C. W. Parker, Jr. (AM '48), manager of the Philadelphia district, Allis-Chalmers Manufacturing Company, has been named to

Conference Papers Open For Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until October 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y., on or before October 27.

58-222 **Design Considerations for Large Industrial Semiconductor Rectifiers.** *G. J. Bowar*

58-917 **Energy Conversion Properties of Induction Machines in Variable-Speed Constant-Frequency Generating Systems.** *M. Riaz*

Reprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

the new position of director of sales promotion in Allis-Chalmers Industries Division.

D. O. Schwennesen (AM '34, M '53), of the Magnetic Metals Company, Camden, N. J., has been elected to the office of vice-president. His duties will include both engineering and managerial responsibilities. Mr. Schwennesen, who joined Magnetic Metals Company in 1956, is a well-known authority in the specialty and small transformer field.

J. W. Weigt (AM '19, M '26), New York branch sales manager, Exide Industrial Division, The Electric Storage Battery Company, has retired after more than 38 years of service with the Philadelphia, Pa., firm. **H. H. Warren** (AM '46) will succeed Mr. Weigt as New York branch sales manager.

Dale Willcox (AM '51), of the Furnas Electric Company, Batavia, Ill., has been appointed project engineer. He will be directly connected with the development and engineering of magnetic controls, drum controllers, pressure switches, pilot devices, and motor control accessories.

R. N. Wagner (AM '44, M '51), assistant chief electrical engineer, Aluminum Company of America, Pittsburgh, Pa., has been appointed chief electrical engineer succeeding **L. N. Grier** (AM '22, F '54), who retired from active service July 1 after 39 years of service. A graduate of Clarkson College of Technology, Potsdam, N. Y., Mr. Wagner has been with Alcoa since 1937. He is past chairman of the Pittsburgh Section of the Institute, and has served on the following AIEE Committees: Chemical Industry (1955-58), Industrial Power Rectifiers (1955-58), and Sections (1955-57).

W. H. Osterle (M '46, F '51), supervisor of planning engineering, West Penn Power Company, Greensburg, Pa., has received a promotion to manager of research and development. This is a new department created within the company's engineering group to co-ordinate the many new developments and advances in electric utility engineering as they apply to West Penn Power planning and operation. The department also will include a computer center at the company's general office. Mr. Osterle is past chairman of the Pittsburgh Section of the Institute. He has served on the AIEE System Engineering Committee (1949-58) and Prize Awards Committee (1958-59).

C. R. Muller (AM '39, M '49), technical assistant to the manager of standards, ITT Laboratories, a division of International Telephone and Telegraph Corporation, Nutley, N. J., was a United States delegate to the annual meeting of the International Electrotechnical Commission in Stockholm, Sweden, July 8-17, 1958. Mr. Muller served as chief delegate to Technical Committee SC40-5 on Basic Climatic Testing.

R. N. Lesnick (AM '51), manager of commercial engineering, Stewart-Warner Electronics, Chicago, Ill., has been appointed chief engineer of the Beltone Hearing Aid Company, Chicago. Mr. Lesnick has served on the AIEE Telegraph Systems Committee (1957-58).

M. H. Kebby (AM '55), of the Lenkurt Electric Company, San Carlos, Calif., has been named product development manager in Lenkurt's Commercial Products Division.

OBITUARIES

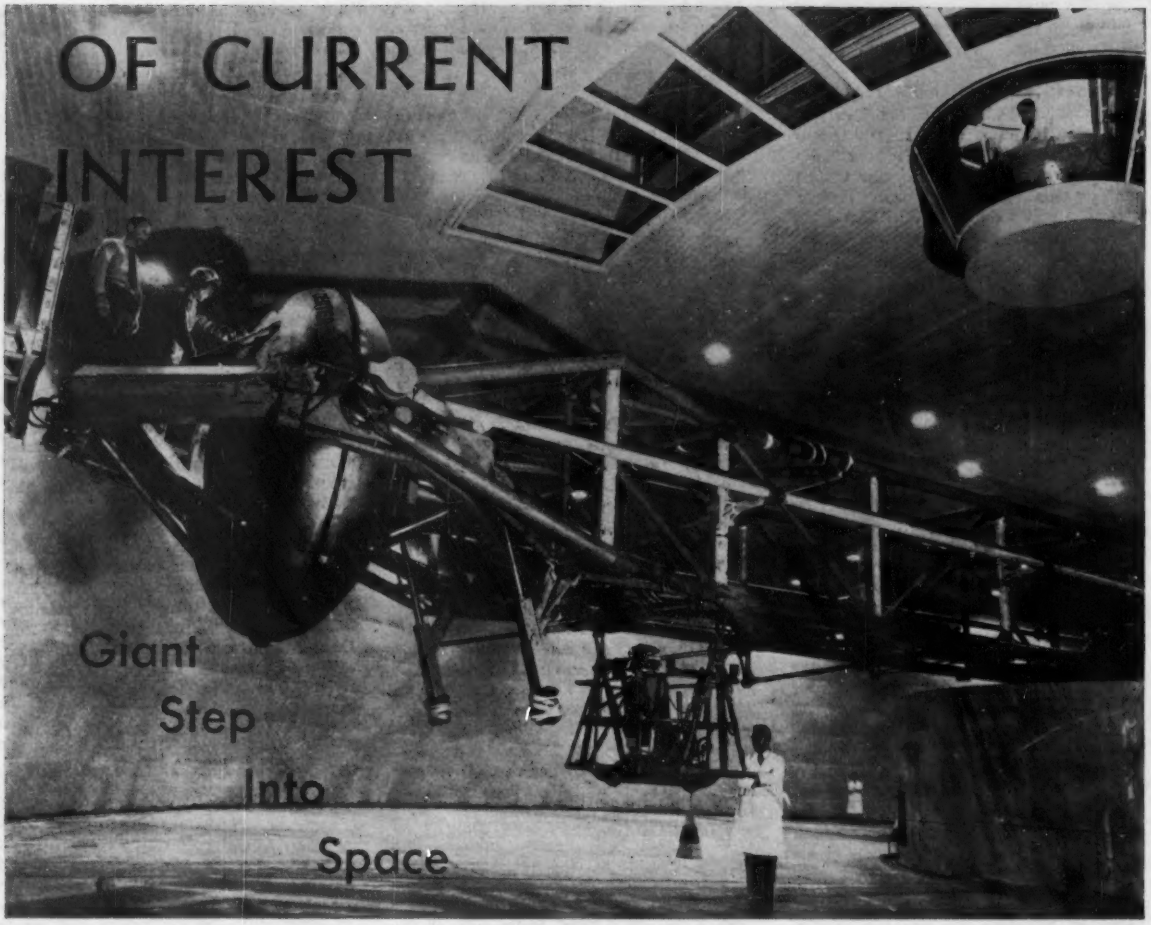
Harold Winthrop Buck (AM '95, M '01, F '12, Member for Life), past president of the AIEE, 1916-17, died recently. He was 85. Mr. Buck, who participated in the harnessing of Niagara Falls to provide electric power, was born in New York, N. Y., on May 7, 1873. He graduated from Yale University in 1894 with the degree of Ph.B., and received the E. E. degree from Columbia School of Mines in 1895. During 1895-96, he was a student in the shops of the General Electric Company (GE) at Schenectady, N. Y., doing experimental work on a-c apparatus for Dr. C. P. Steinmetz. From 1896 to 1900, he was assistant to the chief engineer of the GE lighting department, Schenectady, in which capacity he contributed to the introduction of high-voltage a-c distribution in many parts of the United States. During that same period, he also had charge of much experimental work leading to the development of the oil circuit breaker and other high-voltage devices. In 1900, he was named chief electrical engineer of the Niagara Falls Power Company and allied interests at Niagara, having entire charge of electrical engineering in the design and construction of power house No. 2 on the United States side of the Falls, and the Canadian Niagara Power Company's plant on the Canadian side; also the terminal stations at Buffalo, N. Y., and engineering in connection with the distribution of power in Niagara, Tonawanda, and Buffalo. In 1906, in cooperation with E. M. Hewlett, at Niagara Falls, Mr. Buck carried on experimental work on high-voltage insulators. In 1908, Mr. Buck became vice-president of Viele, Blackwell, Buck, consulting engineers, engaged in the design and construction of hydroelectric and steam power plants and of transmission systems in the United States and Canada. During his career, Mr. Buck presented a number of technical papers before the Institute and other organizations. He was a member of the Franklin Institute, the American Electrochemical Society, and the Engineering Institute of Canada. Mr. Buck had served on numerous general and technical committees of the AIEE including Edison Medal, Executive, Transmission and Distribution, John Fritz Medal Board of Award, and Education.

John Mitchell Drabelle (AM '12, M '17, F '50, Member for Life), consulting engineer on foreign power station design and installation, Allis-Chalmers Manufacturing Company, died recently at the age of 71. Mr. Drabelle was born in Des Moines, Iowa, on December 10, 1886. His engineering degrees included a master's from Purdue University. Mr. Drabelle was a former chief engineer for the Iowa Electric Light and Power Company from which he retired in 1952 after 42 years of service. The author of many technical papers, he was past president of the Midwest Gas Association, the Iowa Public Utilities Association, and the Cedar Rapids Engineers Club. He had served as chairman of the Governor's Committee on Mines and Mining in Iowa, Iowa Civilian Defense Public Utilities Gas and Electric Committee, and other groups. He was a fellow of The American Society of Mechanical Engineers, and a member of the American Gas Association, Edison Electric Institute, and National Association of Power Engineers. In 1950, Mr. Drabelle received the Anson Marsten Award from the Iowa Engineering Society. He served on the following AIEE Committees: Power Stations (1916-17), Membership (1923-25), and Power Generation (1946-49).

Archie Clifton Rogers (M '45), assistant system station superintendent of Appalachian Power Company, Roanoke, Va., died recently. Mr. Rogers was born in Milan County, Tex., on December 8, 1898. He graduated from Texas A&M College in 1923 with the B.S. degree in E.E. He joined Appalachian that same year. A registered professional engineer in the State of West Virginia, Mr. Rogers was a very active member of the Virginia Mountain Section of the Institute.

Manoel Felix de Mayo Behar (AM '37, M '54), vice-president of Instruments Publishing Company and editor emeritus of *Instruments & Automation* magazine, died recently at the age of 69. Mr. Behar, an internationally known figure in the fields of automation and instrumentation, wrote and edited the early literature in the fields. Mr. Behar received his education in France, Switzerland, and England; at Pratt Institute and Columbia University. As an officer in Army Ordnance, he invented several military instruments. He was technical writer for Johns-Mansville Co., 1920-21; research engineer for Brearley Service Organization, 1921-23; advertising manager for Edison Storage Battery Co., 1923, and for C. J. Tagliabue Mfg. Co., 1924-29. From 1929 to 1955, he was editor of *Instruments* magazine in which capacity he earned world recognition. Since 1955, he had served as an active editor emeritus on the staff of *Instruments & Automation* magazine. He was the author of several books and innumerable articles on instrumentation. Mr. Behar was an honorary member of the Instrument Society of America, a fellow of the American Association for the Advancement of Science, life member of the American Society of Mechanical Engineers, charter and life member of the Army Ordnance Association, and member of the American Institute of Physics, American Physical Society, American Association of Physics Teachers, National Society of Professional Engineers, Pittsburgh Physical Society, American Society of Metals, Federation of Atomic Scientists, Southern California Meter Association, and the Institute of Aeronautical Sciences.

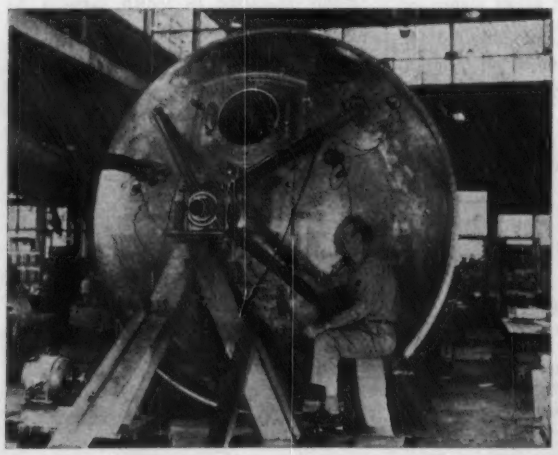
OF CURRENT INTEREST



▲ NAMAL giant centrifuge which is believed to be the largest of its kind in existence, is said to afford the pilot control from within the gondola. Dubbed the "Big Wheel," the experimental unit was designed and built by McKiernan-Terry, Harrison, N. J. The rotor arm and gondola can reach a speed of 180 miles per hour in the space of 7 seconds from a dead stop.

HUMAN REACTIONS to the crushing forces of rocket flight in preparation for man's first venture beyond the Earth's atmosphere are being studied by use of a giant centrifuge. This tremendous piece of equipment has been instrumental in saving lives of test pilots, as well as saving millions of dollars in prototypes.

Travel from the Earth's surface to the fringes of space and back again poses fantastically difficult problems in the design of the rocket ship itself. Just as propeller-driven fighters of World War II were torn apart against the sound barrier, so too the modern space ship risks destruction as it plunges from space at fantastic speeds and strikes the Earth's upper atmosphere. Rock-hard waves of compressed air will bludgeon it, and air friction will bring its surface temperatures to a white heat. It will encounter the same destructive forces that consume meteorites before they can reach the Earth's surface.



GONDOLA for the NAMAL centrifuge undergoing vacuum tests at the McKiernan-Terry plant. Hermetically sealed construction permits exposure of pilot to low-pressure and high-altitude conditions. Strain gauges are connected to critical stress points.

To cope with these conditions, aeronautical scientists have recently succeeded in designing a ship—the North American *X-15*—with the shape, strength, and sensitive control necessary to survive the brutal buffeting of the journey. But what about the pilot? Can his body survive this punishment? How will he react to the violent, crushing forces that confuse his senses? Will he be able to control his ship under these conditions?

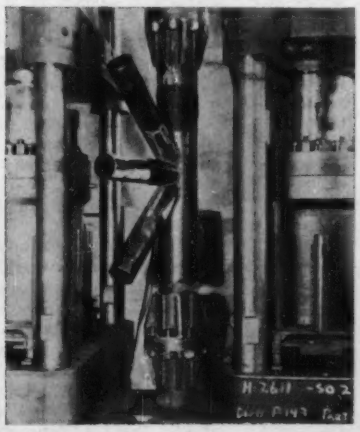
Preparing the Spaceman

The answers to these questions are now being studied at the U.S. Naval Air Development Center at Johnsville, Pa., with the aid of the Naval Aviation Medical

Acceleration Laboratory's (NAMAL) giant human centrifuge. In preparation for a simulated flight into space, the pilot, dressed in a full pressure suit, is seated inside a 10-foot gondola located on the outer end of a 50-foot tubular steel arm. He is faced by a full complement of aircraft instruments and controls, which function as they would in an actual experimental ship. Packed into the gondola around him is a wide range of special devices for observing his physical condition while under "flight" test—sound equipment, television camera, motion picture cameras, and sensitive equipment to monitor his heartbeat and breathing. To simulate his flight environment further, air temperature and pressure within the gondola can be regulated to expose him to a wide range of artificial altitudes.

This gondola—actually a laboratory in itself—is mounted on the end of the huge arm in a mechanism that permits it to be tumbled end over end and sideways at various speeds and in many different, controlled patterns. With the gondola tumbling, the huge arm can be swung at great speeds by its 180-ton motor. The pilot in the gondola can thus be subjected to the same violent, crushing forces that he will experience in actual flight through the Earth's atmosphere.

His all-important ability to function under these forces is studied by aviation medical personnel in a remote-control room in the building housing the centrifuge. From this point, by means of viewing and recording devices connected to the gondola's electrical circuits, they can send him vocal commands and visual stimuli, and immediately view and record his ability to respond correctly and speedily. The results of a series of such tests not only serve to train the pilot, but also often indicate the need for special improvements in pilot restraint and positioning and in the controls and instruments with which he must work. Such



FLANGE CONNECTION undergoing tension test has been pulled apart hydraulically to determine yield point. To determine maximum strength under heavy centrifugal loads, McKiernan-Terry tested critical parts of huge tubular steel centrifuge arm to destruction.

CAMERAS within the gondola provide a record of the reaction of the pilot to simulated flight into space. Muscles in pilot's face show sag under the force of 6 g.

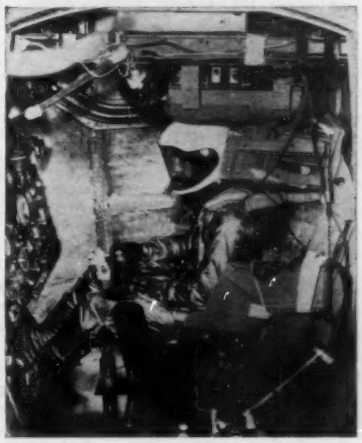
improvements are extremely desirable in order to make handling a sensitive spaceship as foolproof as possible.

Flying the Grounded Spaceship

Great strides have recently been made in the techniques of simulating space flight with the big centrifuge, so that it is now actually possible for the pilot to control—or "fly"—the centrifuge from his position within the gondola. This process, called "dynamic flight simulation," has enabled NAMAL scientists to test the capabilities of the new *X-15* and its pilot thoroughly without endangering lives or costly equipment. To do this, the *X-15*'s designers describe the plane's projected behavior in thousands of mathematical formulas. This mathematical description of flight characteristics is then fed into a large computer which is connected to control the centrifuge in order to make its movements correspond to the natural flight tendencies of a rocket ship. In essence, then, the "educated" computer–centrifuge combination becomes the *X-15* itself, operating on commands from the pilot riding in the gondola.

To complete the flight simulation, the gondola carries a working set of cockpit controls and instruments from the *X-15* itself. Therefore, when the pilot moves the controls, he not only experiences the unique forces of the ship in flight—he also observes the changes in his instruments and, thus, becomes familiar with the cockpit layout, so that flying the new ship comes naturally to him in advance of his first actual test flight.

It is now known that, had it been necessary to conduct these experiments in actual flight—as was the practice with even late model jet fighters—a disaster would have occurred on the first flight beyond the atmosphere. The use of the centrifuge to train and study potential space pilots, and to discover and perfect the finest control techniques before ever leaving the ground, has saved many lives and avoided the needless waste of test



PILOT and equipment both are tested for rocket flight by use of centrifuge. Special equipment for restraint of uncontrolled body movement during violent maneuvers can be seen in detail. High-g forces led to adaptation of right-hand console stick.

aircraft worth many millions of dollars. The fact that the original design of the device, constructed in 1950, contained the potential necessary to encompass the needs of space flight pioneering, is a tribute to the imagination, inventiveness, and workmanship of the people of the U. S. Navy and of McKiernan-Terry, Harrison, N. J., the firm that built the equipment for NAMAL.

Electrolytic Tinning by Controlled Operation of Processes

THE AMERICAN tin plate industry has reached new standards of operation and control with the start-up of United States Steel's newest electrolytic tinning line at the Pittsburg, Calif., plant of Columbia-Geneva Division, according to L. B. Worthington, Division president. The recently completed facility incorporates some of the latest devices and most current processes for producing tin plate to exacting requirements of customers.

The new line is one third longer than a football field. It extends across four bays of the sheet and tin plate mill buildings at Pittsburg Works. Including 60 feet of construction below the ground level, it is equal in height to an eight-story building.

The line can produce in one minute enough tin plate to make 6,000 average

COILS FOR CANS are fed into electrolytic tinning line at speed of up to 1,250 feet per minute. The new facility is the third built by Columbia-Geneva Division at U.S. Steel's Pittsburg Works. Current can be adjusted during line operation.

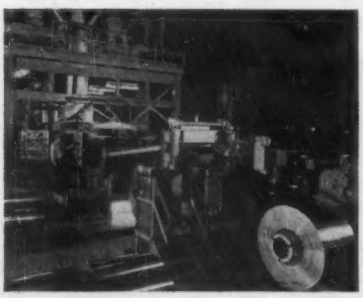
size tin cans. Pittsburg Works is a large producer of tin plate in the West. Output of the plant's two older electrolytic tinning lines has been a major factor in meeting increasing western requirements for packaging foods, beverages, and other products.

Equipment

The new installation is equipped with automatic closed-loop feedback control systems to regulate and synchronize most of the line functions. Included are modulated loop controls, both magnetic and photoelectric, and regulators governing speed, edge position, tension, temperature, and plating current. All of the regulators are synchronized to the speed of the moving steel.

The line employs pin-hole detectors, radiation gauges for measuring steel and coating thickness, flow-line indicators, reflectivity devices for surface inspection, and sheet-classifying equipment. An important factor in the quality control system is a series of memory devices. These automatically cause the cut pieces of tin plate to be placed in separate piles according to quality.

The control devices can operate with the ribbons of steel racing through the line at speeds up to 1,250 feet a minute. They provide a maximum degree of accuracy in quality control through a constant close measurement of the thickness of both the steel and the tin coating. They assure uniformity of finish, accurate classification, and exactness in counting and piling.



NERVE CENTER for control system are these stainless steel panels on the third electrolytic tinning line at U.S. Steel's Columbia-Geneva Division Pittsburg Works. They flank the cleaning and coating tanks on the operating level. Operator is adjusting current.

Production Innovations

Other innovations on the third electrolytic installation at Pittsburg include the use of germanium rectifiers for cleaning and plating the steel, a fire detection system employing heat sensitive cable, and rectifier switching for varying plating capacity.

The "main floor" of the new Pittsburg tinning line is actually at mezzanine level, some 15 feet above the mill floor level. Designed to facilitate maintenance of the large amount of machinery built into the line below main-floor level, it eliminates the older electrolytic tinning lines maintenance problems, where much of the lower level machinery was located in less accessible basement areas.

Color coding provides greater safety, easy identification of specific kinds of equipment, contrast between moving parts and stationary machinery, and control of light for greater eye comfort. As insurance against error by a color-blind person, all vital valves and switches are marked with readable tags.

Processing Methods

Most of the steel used for tin plate production at Pittsburg comes from the Columbia-Geneva plant at Geneva, Utah, in the form of hot-rolled steel coils.

In the initial operation at Pittsburg the steel is processed through one of two continuous pickling lines, where acid treatment removes the hard scale formed in hot rolling at Geneva.

At the entry end of the new electrolytic tinning line, the coils are placed on one of two uncoilers. While one coil is being run through the line, another is placed in position on a second uncoiler, ready to be welded to the tail end of the running coil. To allow the line to continue running while the entry end stops for several seconds to permit welding of the next coil to the end of the coil in process, some 250 feet of uncoiled steel is accumulated in two 80-foot looping pits, 60 feet extending below the floor level and 20 feet extending above the floor.

The steel passes into electrolytic cleaning tanks after which it is scrubbed with brushes and spray rinsed. It then passes through acid pickling tanks to prepare the surface for plating. The actual coating of the steel with tin takes place as the steel is passed at high speed through a series of electrolytic plating tanks. It carries a low-voltage charge of direct-current electricity as it passes around conductor rolls moving from tank to tank. Bars of tin measuring 6 feet long and 2 by 3 inches thick are hung vertically in the tanks. As the steel passes between the rows of tin bars immersed in an acid electrolyte, the electric current draws the tin from the bars and deposits it on the surface of the steel.

The new Pittsburg facility has a plating capacity of approximately 100,000 amperes. Precise controls regulate the amperes in proportion to the line speed to give the desired amount of tin coating. A unique arrangement of electrical controls permits plating a heavier coating on one side of the steel than the other, as is required by some uses. This so-called "differential coating" provides a heavier coating for the inside of cans when increased resistance against corrosion is necessary.

After the melting process, the coated steel is treated chemically to preserve its bright appearance and to provide a thin, dense oxide coating. Sprays remove any excess acid, and a thin film of lubricant is applied.

The finished tin plate from the new Pittsburg line is shipped to can manufacturers either in cut sheets or in coil form. An innovation on the line is an extra uncoiling mandrel which will permit the shearing of coils previously made while other coils of tin plate are being produced. Shipment of electrolytic tin plate in coil form is a relatively new development in the industry.

The end use of most tin plate is the familiar tin can on the grocery shelf, which is actually more than 99 per cent steel and less than one per cent tin.

USS Nautilus Makes "Under-the-Ice" History

The recent epoch-making "under the ice pack" transpolar trip of the U. S. Navy's *Nautilus* drew high commendation from Government and civilian sources on behalf of the officers and crew of the submarine as well as the industries whose equipment contributed to the success of the venture.

"For the trip we were equipped with the most modern navigational equipment in the Fleet," commented Comdr. W. R. Anderson, commanding officer of the *Nautilus*, who was awarded the Legion of Merit for the expedition. Included among the navigational aids were gyrocompasses, automatic depth and course-keeping controls, a celestial altitude recorder, and an aircraft-type *C-11* Gyrosyn compass system especially designed for use in polar regions, all developed by Sperry Gyroscope Company, Division of Sperry Rand Corporation, Great Neck, N.Y.

The submarine's automatic depth and course-keeping controls may be compared roughly to the automatic pilots used on aircraft, enabling a "planesman" to make ultrafine adjustments in steering direction. The lightweight compass system employs a technique which cuts random nonfloated gyro drift 90%. These gyros, which the company calls "Rotorace" (*Electrical Engineering*, May 1958, pp. 471-72) are of particular importance in upper latitude explorations.

In a telegram to Westinghouse Electric Corporation, Pittsburgh, Pa., Comdr. Anderson praised the performance of the nuclear engine designed and developed for the *Nautilus* by that company's Bettis Atomic Power Division, working under

the direction of and in technical co-operation with the Naval Reactors Branch of the U. S. Atomic Energy Commission. Representative James Fulton of Pennsylvania, in a congratulatory message sent to Westinghouse, commented "As a member of the House Foreign Affairs Committee and of the new Select Committee for Exploration in Astronautics and Space I am strongly recommending . . . to Dr. James R. Killian, the President's Scientific Advisor as well as to the Advanced Research Projects Agency of the Department of Defense that the Westinghouse atomic and nuclear team be kept intact and its fine accomplishments be broadened into research and development on nuclear engines and power for space vehicles and intercontinental ballistic missiles."

"Hot" or "Cold" Shoot Used in Acceleration Test

From a dead stop, the Lockheed *X-7* missile surges forward at an acceleration that would crush a body under two tons of weight, hits top speed, then slams to a stop equivalent to a 60 mph head-on crash into a solid brick wall. All this in only 0.04 of a second—and a scant 2 feet of travel distance. This is the kind of punishment modern missiles, with their delicate and precision parts, must withstand if they are to perform properly.

The "G-Shooter," a special device developed by the Lockheed Missile Systems Division's engineers, puts the missiles through a rugged ground test of electronic equipment and systems before launch high into the upper atmosphere to flight-prove new and giant ramjet engines.

To conduct the test, the *X-7* is mounted on the rails of the G-Shooter which blasts the bird to an 18 g acceleration—18 times the force of gravity—to simulate the fantastic drive when the missile is rocketed to a sudden faster-than-sound speed seconds after launch. The test gives Lockheed engineers a realistic look at how the many instruments and electronic systems in the missile will stand the tremendous shock of the rocket boost needed to bring the *X-7* to a speed where its ramjet engine takes over.

Set for a test run, the *X-7* rests on the G-Shooter's rails while a pressure of 2,100 pounds per square inch (psi) is built up in a cylinder containing a piston. The pressure is released with a deafening roar, and the piston flashes forward, pushing the missile at breakneck speed down the steel ribbons.

Eight bands of nylon webbing are strung under the rails to act as brakes and to keep the bird from flying off the shooter as it hits a speed of 23 feet per second in only 6 inches. Four of the webs stretch to their limits, absorbing the tremendous shock, then snap as planned to prevent rebound. The remaining four are there as a safety factor.

Two techniques are used in the tests, it was explained, depending upon the missile model or system to be checked out. One is the "hot" shoot during which all of the electronic systems are operating and sending radio signals to monitoring consoles nearby. The other is the "cold" shoot without the systems running and where the missile is taken into the shop for a system checkout. The cold shoots are used for those birds whose systems have been through the punishment before, while the hot shoots are given missiles which have design changes, new systems, or new major components. In either case, the data is carefully analyzed and the trouble spots pinpointed before the missile is turned loose for flight.

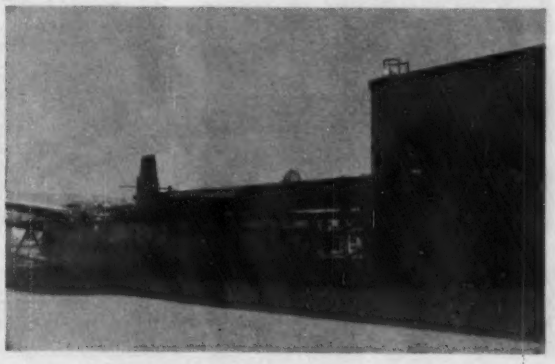
Once past the g test and other final checks, the *X-7* is air-launched from a *B-50* over the desert range, slashing a vapor trail high in the New Mexico sky on another test of the powerful ramjet engines which will power some of the nation's new defense weapons.

Heliostat Keeps Furnace Tracking Sun

Man has taken a lesson from sunflowers to help him push back the frontiers of science by developing a solar furnace equipped with a sun-tracking heliostat to keep the furnace pointed at the sun throughout the day.

Working on the principle of a sunflower, which is reputed to keep its face pointed constantly at the sun, the heliostat-equipped solar furnace was designed and built by missile engineers in General Electric's Missile and Ordnance Systems Department, Philadelphia, Pa.

Installed in the department's Aerosciences Laboratory, where high-temperature studies are conducted with many



SUPERACCELERATION is achieved by this Lockheed *X-7* missile (said to be the fastest and highest flying air-breathing missile in the free world) as it blasts the scant distance of 2 feet along the rails of the specially designed "G-Shooter" at Holloman Air Force Base Missile Development Center. Details are still classified.

Future Meetings of Other Societies

Illinois Institute of Technology

Conference on Radio Interference Reduction, sponsored by Armour Research Foundation & U. S. Army Signal Engineering Labs, Oct 1-2, Museum of Science & Industry, Chicago, Ill. S. I. Cohn, Elec Engg Research Dept, ARF of IIT, 10 W 35 St, Chicago 16, Ill.

5th Annual Computer Applications Symposium, Oct 29-30, Morrison Hotel, Chicago, Ill. Frederick Bock, Elec Engg Res Dept, ARF of IIT, same.

The Institute of Radio Engineers

Symposium on Extended Range & Space Transmission, joint Geo Washington U, Oct 6-8, Lisner Auditorium, GWU, Washington, D. C. Harry Fine, 1233 Valley Ave, SE, Washington 24, D. C.

4th National Aeronautical-Communications Symposium, Communications Systems, Oct 20-21, Hotel Utica, Utica, N. Y. R. C. Benoit, 138 Riverview Pkwy, Rome, N. Y.

URSI Fall Meeting, Oct 21-22, Penn State U, University Park, Pa. S. Silver, U. S. Natl Comm URSI, 2101 Constitution Ave, Washington 25, D. C.

National Simulation Conference, Oct 23-25, Dallas, Texas. L. B. Wadel, 3905 Centenary Dr, Dallas 25, Texas

East Coast Aeronautical & Navigational Electronics Conference, Oct 27-29, Lord Baltimore Hotel & 7th Regiment Armory, Baltimore, Md. H. S. Rutstein, Eastern Assoc, 5612 Belleville Ave, Baltimore 7, Md.

1958 Electron Devices Meeting, Oct 30-Nov 1, Shoreham Hotel, Washington, D. C. R. K. Kilbon, RCA Labs, Princeton, N. J

National Association of Corrosion Engineers

Northeast Region Conference, Oct 6-8, Boston, Mass. M. M. Jacobson, Watertown Arsenal Labs, Watertown 72, Mass.

South Central Region Conference & Exhibition, Oct 20-24, Roosevelt Hotel, New Orleans, La. W. F. Oxford, Jr. Sun Oil Co, Beaumont, Texas.

Pennsylvania Electric Association, Fall Meeting, Meter Committee, Oct 13-14, The Wentworth by-the-Sea, Portsmouth, N.H. J. B. Smith, c/oPEA Meter Meeting, above hotel.

ASCE, Convention, Oct 13-17, New York, N.Y. D. Reynolds, ASCE, 33 W 39 St, New York 18, N. Y.

American Institute of Mining, Metallurgical, & Petroleum Engineers, Inc.

Southern Calif Petroleum Section Fall Meeting, Oct 16-17, Biltmore Hotel, Los Angeles, Calif. H. N. Appleton, AIME, 29 W 39 St, New York 18, N. Y.

Mining-Metallurgicals Mid-America Minerals Conference, Oct. 23-25, Chase-Park Plaza Hotels, St. Louis, Mo. H. N. Appleton, AIME, same.

SMPTE, 84th Semiannual Convention, Oct 20-24, Sheraton-Cadillac Hotel, Detroit, Mich. C. E. Heppberger, 510 White Oak Dr, Naperville, Ill.

National Safety Council, 46th Annual Congress & Exposition, Oct 20-24, Chicago, Ill. R. L. Forney, National Safety Council, 425 N Michigan Ave, Chicago 11, Ill.

American Vacuum Society, 5th National Vacuum Symposium, Oct 22-24, Sir Francis Drake Hotel, San Francisco, Calif. C. B. Willingham, Mellon Institute, 4400 5th Ave, Pittsburgh 13, Pa.

NSPE, Fall Meeting, Oct 22-25, St. Francis Hotel, San Francisco, Calif. J. A. Sontheimer, Calif Soc of Prof Engs, c/o above hotel.

Electronic Industries Association

Radio Fall Meeting, Oct 27-28, Sheraton Hotel, Rochester, N.Y. J. A. Caffiaux, EIA, 650 Salmon Tower, 11 W 42 St, New York 36, N. Y.

Conference on Reliable Electrical Connections, Dec 2-4, Statler Hilton Hotel, Dallas, Texas. R. G. Roesch, 1068 S Clinton St, Syracuse 4, N. Y.

types of extreme heat-producing equipment, this solar furnace is used to conduct relatively high-temperature studies in an uncontaminated or a controlled atmosphere.

The solar furnace is coming more and more into use. Its advantages are that it can be operated very cheaply, it will give very clean heat, and it is simple in operation. Solar furnaces are particularly useful in relatively cloudless areas, including the U. S. Southwest.

On cloudy days, the solar furnace at G-E is used inside and operated by shining a searchlight into it as a substitute for the sun. Its principle of operation remains the same—that is, the furnace, with a large concave reflector in the back, focuses the heat given off by the arc in the searchlight just as it focuses the rays of the sun. The same effect is achieved by holding a reading glass over paper to burn a small hole or to set the paper afire.

The solar furnace at the Aerosciences Laboratory was made from a converted Army searchlight. Engineers added the crossed metal beams ("spider") to hold the cylinder containing the specimen and a quartz chamber that can be evacuated to permit testing specimens in a vacuum. The quartz chamber can also be filled with mixtures of gasses to resemble any desired atmospheric condition.

Temperatures achieved with a solar furnace using a searchlight for the heat source are about 5,000 F and using the sunlight about 6,000 F. Although such relatively low temperatures are not applicable in many areas, the solar furnace provides an excellent tool when moderate and pure heat is required.

HELIOSTAT keeps GE Aerosciences Laboratory solar furnace pointed constantly at the sun.

To achieve higher temperatures, Aerosciences engineers go to such other tools in their laboratory as fluid-stabilized arcs and shock tunnels. The complementary operation of these tools gives the needed heat sources for almost any phase of high-temperature research and development.

Automatic Sun Louvers Feature of Aluminum Showcase

A VIRGINIA garden is the setting for the new aluminum office building of the Reynolds Metals Company in Richmond. From the exterior, almost everything visible is either aluminum or glass. Aluminum used throughout the building includes a large system of automatic sun louvers, movable office partitions, acoustical and light-diffusing ceilings, a new line of aluminum office furniture, aluminum fiber yarn draperies and carpeting, and most hardware including all wiring and cables. The square-shaped 4-level structure is capable of housing 1,000 employees.

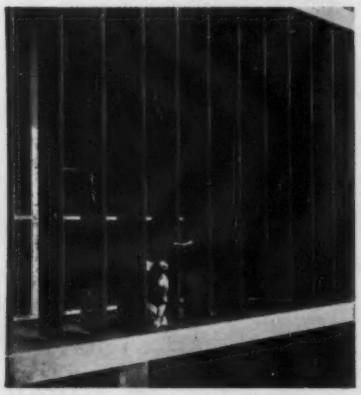
Building Details

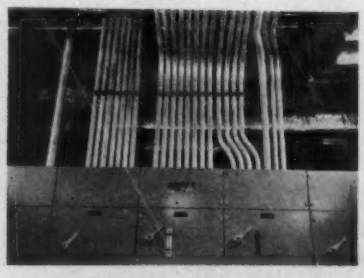
Through gray-tinted glareproof glass walls, employees look out onto a 253-foot reflecting pool bordered with willow oaks. The terraced landscape has all types of flowers, and there is also a classical courtyard with a 40-foot magnolia tree and a leaping fountain.

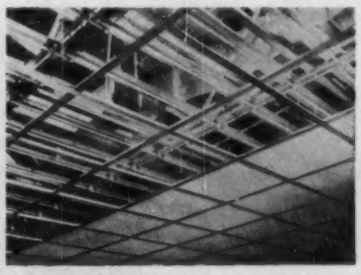
Giant color-anodized aluminum sun louvers—880 in number, each 14 feet high and 22 inches wide—shield the glass walls of the building from heat and glare, and reduce the air-conditioning load. The louvers protect the glass walls from the sun, and provide proper ventilation between the louvers and the glass, thus substantially reducing the heat load on the critical east–west exposures. Geared to an astronomical clock which will anticipate the movements of the sun through the year 2100 A.D., the louvers are operated by two 7.5-hp motors and two 5-hp motors governed by a complex control made and designed by Lemlar Manufacturing Co., Gardena, Calif. The louvers change position several times a day only slightly in advance of the sun's movement so that there is a minimum restriction placed on the view and the entering daylight. Barring power failures, the master clock will keep the control system properly adjusted until the year 2100.

Inasmuch as the building is totally enclosed by fixed glass panels, the reliability and efficiency of the heating, ventilating, and air-conditioning system is of primary importance. To accommodate the architectural and occupancy requirements, it was decided to use a zoned air system with booster heaters. Provision was made for individual thermostatic controls as required for complete flexibility now or in any future office arrangements. Perimeter heating is achieved by hot-water convectors located in attractive aluminum grilles under the glass panels. These convectors are controlled by an outside thermostat in order to be completely responsive to variations in the outdoor temperature. Climate inside the building is centrally monitored and controlled from a push-button Minneapolis-Honeywell Supervisory DataCenter from which an attendant can modify temperatures throughout the building in response to employee desires. Control operation of steam and hot-water boilers, chillers, and fans is also done from this point.

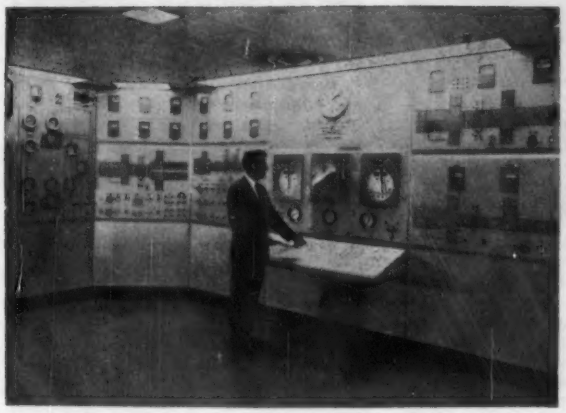
Air distribution is accomplished by 10 separate fan systems which take fresh air from a common plenum, the intake grilles for which are located in the first-level terrace. This air is cooled or heated as required, filtered, dehumidified, and distributed throughout the building in soundproof aluminum ducts. The DataCenter control room engineer can start or



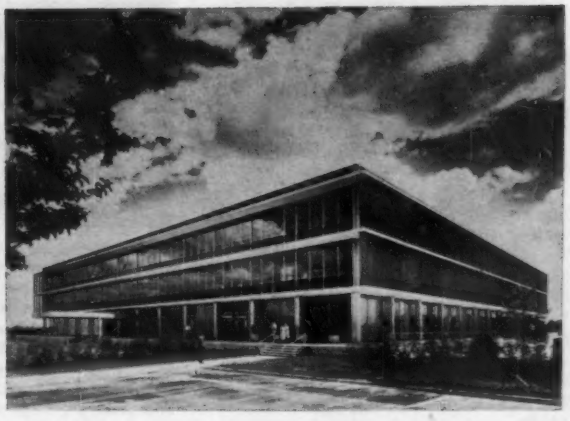




MASTER CLOCK controls 880 sun louvers (*left*) on eastern and western face of building, thus reducing air-conditioning load. Motor control room (*above left*) is where voltage is transferred. Honeycomb ceiling cutaway (*above right*) shows wiring, aluminum lighting fixtures, and light diffusers.



ELECTRICALLY OPERATED, the giant Supervisor DataCenter gives building engineer push-button control of heating and air-conditioning equipment and operations throughout the building. The Minneapolis-Honeywell built unit was designed so that aluminum was used throughout the DataCenter.



SUN LOUVERS, made of aluminum, shield the glass walls of the new consolidated headquarters building of the Reynolds Metals Company. All of the electrical wiring and cables throughout the 4-level building are of aluminum as well as the major part of the building itself.

stop any piece of equipment, check its performance, and determine the temperature, humidity, and pressure at various points throughout the building.

Electrical Features

To preserve the attractive appearance of the building and landscaping, electric power service is carried underground to the transformer bank located in the lower level adjacent to the garage. Natural ventilation for these transformers was a critical consideration and is provided by a masonry baffle so constructed that cooling air is brought into one side of the grille by the stack effect of the warm air exhausting from the other side. Electrical distribution is accomplished to the maximum extent by use of aluminum cable in aluminum conduit. The building's power distribution is from the drawout switchgear by means of a 3,000-ampere overhead aluminum bus duct to the a-c motor control board, and then by aluminum cables in 3-inch aluminum conduit to panels and power transformers. Aluminum lighting fixtures are used to carry the 19,000 fluorescent tubes, and Pfaff & Kendall aluminum lighting standards are used in the parking areas.

Three sets of escalators by Westinghouse are installed from the first level to the third level. They operate at 120 foot-per-minute speed, making them the fastest installation known to exist. Two passenger elevators and a freight elevator complete the vertical passageways, all of aluminum.

Executive offices are connected by motorized sliding aluminum doors. A meeting room which seats 100 in comfortable armchairs is equipped with Cinemascope and stereophonic sound facilities and has an aluminum saw-toothed ceiling which is lowered to project voices of speakers on the platform. It is raised and lowered by electric motors.

Cafeteria and sandwich bar combined can accommodate 2,000 persons during lunch hours each day. Special equipment includes water faucets operated by electric eyes, a radar range, walk-in refrigerators, and dumbwaiters. There are also four special dining rooms, and two other fully equipped kitchens.

The dial switchboard is served by 50 local trunk lines, 50 tie lines to other Reynolds switchboards in the Richmond area, 11 direct long distance lines to the telephone company, and 31 private long distance lines to company plants and offices throughout the country. The company is the seventh largest private long distance lines user in the Bell System, with 12,600 miles of lines.

Fire Protection. An 85-hp Peerless diesel electric fire pump and a two-stage pump (size: 4-inch: capacity: 500 gallons per minute) powered by a 50-hp Westinghouse engine provides emergency water pressure for the fire-fighting system.

Heating. Two preferred Utilities Mfg. Corp. 300-hp unit steam generators are used, with a boiler load of 9.5 million Btu/hour and design pressure of 15 psig each, with a top rating of 10,350 pounds of steam per hour at 212 F. Operation is fully automatic with boiler feed water return system and condensate tank furnished by Preferred Utilities. Each boiler has a horizontal rotary oil burner with automatic gas ignition and burns No. 6 fuel oil (with all necessary controls). Fuel oil is preheated by a steam heater with an auxiliary 42-kw electric oil heater for standby operations. Steam boilers are operating at 14 psig high and 10 psig low.

Steam is supplied to kitchen equipment at boiler pressure. Steam is also supplied to heat the two domestic hot water storage tanks for building utilities. Direct heating for the building is furnished by one Patterson Kelly steam–hot water converter supplying 26,500 gallons per hour to perimeter heating, which is the baseboard fin type, having convectors under windows in the cafeteria, second and third levels, the medical center and solarium, and in the penthouse.

A separate boiler, Electro Steam Generator Corporation, type H.F.D.-48, generates steam for the health area steam room at operating steam pressure, 0-15 psig; Btu capacity (at steam outlet 100%) 160,331; 440-volt 60-cycle 3-phase a-c.

Hot water heating is circulated by Worthington circulating pumps located in the boiler room under hot water converters.

Air Conditioning and Ventilation. The system is a low-pressure air distribution system (capacity: 292,400 cubic feet per minute) and includes electrostatic filters, cooling coils, system reheat coils, and booster coils for varying load requirements. The main air-conditioning system is supplemented by two package air-conditioning units to accommodate special zoning requirements in the training area on the lower level and health area in the penthouse.

Two 600-ton York Refrigeration Company centrifugal compressors and condensers are also controlled at the DataCenter. The condenser water is recooled by a 2-cell Marley spray cooling tower. Air is filtered by 13,000-volt electrostatic filters which eliminate particles as small as 1,000th of a micron, including smoke.

Separate exhaust fans are provided for rest rooms, the dishwasher room, transformer rooms, the Ozalid machine room, the movie projection room, the health area and steam room, and kitchen hoods.

Electrical System. Electric service is provided by the Virginia Electric & Power Company from a 13.8-kv pole line running along Broad Street Road adjacent to the property. There are two transformers each rated 1,500 kva, 13.8 kv/480/277 volts, 3 phase, 4 wire, 60 cycles. There is a spare underground duct for emergency, in case of cable failure.

The transformer bank is connected to the drawout switchgear located in the electric service room adjacent to the transformer vault by means of 1,500-MCM type ABV cable in cable trays. The drawout switchgear has 60,000 amperes interrupting capacity. Each circuit breaker protects a feeder line. Electric power is brought to lighting panels located at each core and

each floor of the building. Electric service for fluorescent lighting on the upper two levels is furnished at 480/277 volts. Incandescent lighting on the first level, and in the cafeteria on the lower level requires an extensive power load. To furnish electric service, 150-kva, 480/120/208 volts, 3-phase, 4-wire transformers are located in the core area for building service.

Floor outlets have 120-volt service to furnish electric power for office typewriters, adding machines, etc., provided by means of an underfloor duct system on the lower and first level. Power is furnished by a 9-kva, 480/120-volt, 3-phase transformer located in each core space on each floor. A 60-cell Exide storage battery system equipped with automatic charger and automatic transfer switch provides standby power for all exit lights, and selected night lights.

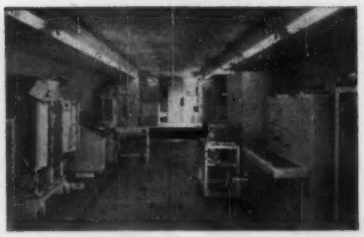
Lighting. The office areas in the lower level are lighted by Curtis Lighting Company fluorescent troffers recessed in the acoustical metal-pan ceilings. The second and third levels are lighted by a Curtis grid assembly. The basic unit is 10 feet 4 inches by 10 feet 4 inches and consists of 16 slimline, cool white, fluorescent lamps operating at 277 volts and 120 milliamperes. The ceiling is made of Honeylite Hexcel aluminum diffuser panels. The hexagonal cells are ⅝ inch by ⅝ inch giving a 45-degree cutoff.

Lighting for executive offices, lobbies, board rooms, and other selected areas are by means of incandescent downlights manufactured by Kurt-Versen Company. These units are internally baffled and are plastered into the ceiling.

Sound System. Programmed music by Muzak is brought into the building by leased telephone lines. A customer-owned amplifier system distributes the music to 345 loudspeakers located throughout the building. Volume control is provided on a zone basis for large office spaces, and by individual volume control for executive offices. Through the same sound distribution system other program material can be provided, such as from AM–FM radio, tape recordings, and records. Emergency preset high-volume announcements for civilian defense or fire alarm can be made by selected personnel. Special systems include a kitchen intercom, a main lobby paging unit, an engineering department unit, and a separate meeting room and board room sound system.

Trailerized AEW Simulator Trains Crews Safely on Ground

Utilizing the Emerson Radio & Phonograph Corporation resources and facilities, the trainer section of its Government Electronics Division, under contract to the Air Materiel Command for the Wright Air Development Center (WADC) at Wright-Patterson Air Force Base in Dayton, Ohio, has developed a trailerized system which provides training for crews that will man Airborne Early Warning (AEW) equipment which is installed in several of our military planes. With this system, it is possible to give effective training to large numbers of crews on the ground without the expense and the risk involved in training them while in actual flight.



INTERIOR of simulator trailer where instructors operate equipment that generates simulated echo signals. This trailer, part of the AEW trainer developed by the Emerson Government Electronics Division in conjunction with WADC, is provided with a special mechanism that permits the floor to be folded back and the side walls to be moved together to permit the vehicle to be transported to various training centers as required.

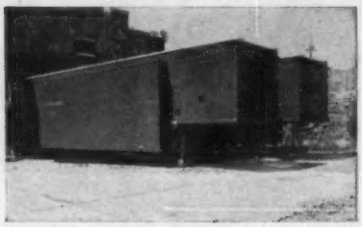
AEW is part of the alarm system established by the Department of Defense to give warning of possible surprise attack by enemy aircraft.

Each AEW trainer consists of two completely air-conditioned trailers. One trailer is built to simulate in every detail a compartment that houses all radar, radio, and internal communications equipment found in operational aircraft. Actual flight conditions are duplicated, and even the sound of the motors is realistic. The crew being instructed occupies this trailer.

The other trailer contains all simulated signal and monitoring equipment for supplying simulated echo signals to the first trailer. Instructors in the second trailer feed and check on problems presented to the crews being trained by manipulating the target-generating equipment, the intercom system, and the simulated radio communications apparatus. These generators contain facilities for providing several hundred simulated "enemy" targets and 12 "friendly" targets. All targets can be presented to simulate relative motion and each trainee is required to obtain, plot, and transmit information with respect to the numbers and types of enemy aircraft assigned to him, and their courses, speeds, altitudes, and compositions as he would be required to do in real combat situations.

In actual practice this data is transmitted to CIC (Combat Information Center) which assembles and interprets all information received from similar AEW aircraft.

In the course of a simulated mission over a prescribed area, they are not only given training in reading and interpreting radar data, but also they are required actually to plot on a large board all of the other aircraft located in their area. In a like manner, certain designated members of the crew undergoing training operate the simulated radio equipment linking communications between their plane and other planes or ground stations under exactly the same conditions they would encounter on an actual mission. In an effort to achieve complete realism, noise and fading can be introduced into the simulated radio communications net as well as into the intercommunicating set in the plane to such an extent that experienced crews who have flown many real missions, and who have operated the training apparatus, have reported that duplication of authentic equipment and effects as encountered by them in actual flight has been very closely approximated.



TRAINER and simulator trailers side by side as they would appear in operation with sides extended. Both of the Emerson-WADC trailer-trainer sections contain complete and self-sustaining power plants for supplying air conditioning and electrical facilities required to operate all equipment. The interior of the trainer trailer is built to resemble an AEW aircraft in flight.

Cost-Competitive Nuclear Electricity Research

The search for electricity from nuclear fission power that would be cost-competitive with electricity from conventional fuels, has been joined by a group of eight investor-owned utility companies in the Rocky Mountain and Pacific states.

They will work with the General Atomic Division of General Dynamics Corporation in a 2-year major research program, it was announced by Dr. Frederic de Hoffmann, general manager of General Atomic and a vice-president of General Dynamics.

The eight companies, to be known as the Rocky Mountain–Pacific Nuclear Research Group, will provide in excess of $500,000 during the next 2 years to further General Atomic's already multimillion dollar research effort.

The member companies are: Arizona Public Service Company, California Electric Power Company, Pacific Power & Light Company, Portland General Electric Company, Public Service Company of Colorado, Public Service Company of New Mexico, Utah Power & Light Company, and Washington Water Power Company.

In addition, the San Diego Gas & Electric Company for the past year has been co-operating with General Atomic in research directed toward economic nuclear fission power.

For many years, it has been known that electricity can be generated by applying heat to the junction of two metals. This principle is used in its most common form in the thermocouple, which is a means of detecting temperature by recording electric voltage.

Thermoelectricity, in its broadest sense, is a study of phenomena which convert heat into electricity, without the intermediate process of rotating machinery such as turbines. Thus, the process of thermoelectricity is often referred to as "direct conversion of electricity."

Scientists have succeeded in producing practical thermoelectric devices, but their efficiency for conversion of heat into electricity is low. Power generating systems, such as the modern power plant burning oil or coal, achieve a conversion efficiency of about 30%. The thermoelectric devices produced to date have an over-all efficiency of only a few per cent. Recently, reports of several groups, particularly Soviet scientists, have claimed practical devices with an over-all efficiency of as much as 10%. Such efficiencies are, of course, too small to be used for stationary power installations, but they have been used to produce a few watts of power.

Among the principles which will be investigated under the research program announced will be the following:

1. Methods using intrinsic semiconductors which become reasonable conductors of electricity at elevated temperatures. Since such materials are of a high purity, not depending on atoms of a second material for their properties as is the case with extrinsic semiconductors, their properties do not change even after long times at very high temperatures. A good deal of exploratory work, both theoretical and experimental, must be done before the proper materials can be found.

2. Thermionic devices. Since the efficiency of a thermocouple is decreased by the conduction of heat through it, it is logical to consider materials which are good thermal insulators for thermoelectric elements. Except for radiation, an evacuated space is a perfect insulator. When the space is surrounded by thermionically emitting walls, the electron gas contained within these walls will then be a conductor of electricity and exhibit a large thermoelectric power. It will be necessary to design the device so that heat losses by radiation and supporting structures are kept to a minimum.

It appears that the higher the temperature of the heat source, the greater is the likelihood that highly efficient conversion processes can be found. For efficient thermoelectric conversion, materials must have a good electrical conductivity and a poor thermal conductivity. Research in the temperature range from 1,500 F to 2,000 F has not been stressed in industrial thermoelectric research up to this time. With the advent of high-temperature nuclear reactors which may have working fluids or gases in this temperature range, a new opportunity for productive research is opened up which will be explored under this program.

The research in solid-state physics will provide the answer to this problem which is a real challenge to the scientist and engineer. Efforts made in the solid-state physics and the nuclear field must be combined to make as great a step forward in the conversion processes as has been made in the nature of the fuel itself.

Any thermoelectric device which would operate in the reactor would have to be able to withstand the radiations. Therefore, if radiation-resistant thermoelectric devices can be made, they could be introduced directly into the reactor without the use of external heat exchangers.

Improve Insulation for Open-Type Motors

Silicone-rubber and epoxy resins are being advanced as improved methods of insulation for open-type motors, thereby increasing their areas of application. Developed by Allis-Chalmers Manufacturing Company, Milwaukee, Wis., all-silicone-rubber insulating systems, called "Silco-Flex," are being used for form-wound stator coils in large motors. The epoxy-encapsulated coil structures are utilized for field windings of large synchronous motor rotors and for stators of smaller-frame motors with random or mesh-wound coils.

CUTAWAY PORTION of "integrated" field coil shows epoxy-filled area of Class H field coil for high-temperature service on synchronous motors and generators.

Silicone-rubber insulation for coil windings is vulcanized into a solid dielectric wall without joints, voids, or breaks. For all practical purposes, it is unaffected by humid conditions. Because silicone-rubber insulation is moisture repellent even in high humidity, condensate which may form will do no damage. Insulation resistance is reduced very slightly after long periods of immersion, but not to the point of electrical breakdown.

Encapsulated stator windings are equally well sealed. Extensive underwater tests of open motors with epoxy-encapsulated stators at full load proved the structure impervious to moisture. Either insulation reduces the need for protection in the frame construction. Both types of insulation are being utilized by the company in its "Super-Seal" line of open motors.

The addition of epoxy resins has moved the company's integrated" field coil construction past previous Class B limits to high-temperature (180 C) service on synchronous motors and generators. The integrated coil structure is a complete insulation system rather than an outer wrapper. Conductors are locked together and to the field pole—sealed completely from dirt and moisture. Use of high-temperature materials protects the structure against heat aging.

Advantages of the improved insulation methods in open motors noted by the company include complete protection of bearing surfaces and lubricants under any ambient conditions, leading to wider application in fields such as chemical, paper, petroleum, metals, and rock products; economy because of greater protection of parts; and ease of maintenance.

X-Ray Amplifier Permits Room-Light Viewing

Hospital tests of an experimental thin-screen X-ray amplifying panel indicate that the device "may ultimately provide the ideal X-ray amplifier," stated Dr. E. W. Godfrey, chief radiologist of Princeton Hospital, Princeton, N.J. In a report to the Rocky Mountain Radiological Society, Denver, Colo., he described evaluation tests of the experimental amplifier with patients at Princeton Hospital and the University Hospital of the University of Pennsylvania in Philadelphia. The experimental panel was developed at Radio Corporation of America's David Sarnoff Research Center, Princeton, N.J., by Benjamin Kazan, who was a coauthor with Dr. Godfrey of the report given to radiologists.

The device consists basically of two special materials arranged in adjoining layers sandwiched between transparent electrodes to form a screen about ¼ inch thick and 12 inches square. One of the materials is a photoconductive powder which conducts current only when it is exposed to X-ray radiation or light. The other is an electroluminescent phosphor, also in powder form, which emits a bright light when a current is passed through it.

When an X-ray image falls on the photoconductive layer, the material acts as an electrical "valve," allowing the current to pass through to the electroluminescent layer in a pattern corresponding to the image. The result is a reproduction of the X-ray image in bright visible light emitted by the electroluminescent material. Having a thin-panel form, the amplifier can be substituted for a conventional fluoroscopic screen, producing bright images that can be viewed in moderate room light. The experimental amplifier in its present stage requires a total exposure comparable to that of highly sensitive X-ray film, the image persisting on the screen over a period of up to 30 seconds and providing temporary storage of picture information.

The amplifier has been put through "exploratory" tests with patients and with "phantoms," or simulated sections of the human anatomy, under a variety of conditions. With the patients, the device was

used to view limited areas of the neck and chest, and to examine hip-pinning results. During the various tests the image on the amplifier could be viewed directly "through the lead glass window of the therapy room or at close range by entering the room during the decay of the image with the X rays off." Among the useful characteristics of the amplifier in its present stage of development, were listed its large area, simplicity of operation, easy adaptability to existing X-ray equipment, amplification of X-ray image brightness to 100 times that of a conventional fluoroscopic screen, its high contrast, and the storage of images.

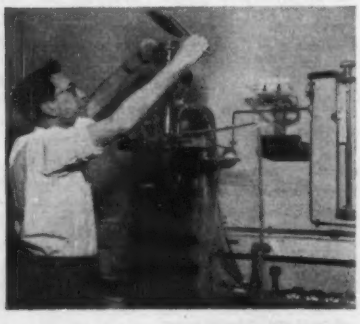
Compound Exhibits Ferromagnetic Properties

Ferromagnetism at low temperatures has been discovered in an intermetallic compound which does not contain any of the commonly known ferromagnetic elements. This discovery, made by B. T. Matthias at Bell Telephone Laboratories, New York, N. Y., was achieved while studying the properties of a zirconium zinc compound ($ZrZn_2$) at low temperature.

The behavior of zirconium zinc indicates that ferromagnetic and perhaps antiferromagnetic compounds may be formed by the combination of many more metals than had been supposed until now. Thus, the discovery opens up an entirely new field for scientific exploration.

Heretofore, no ferromagnetic intermetallic compound was known that did not contain any ferromagnetic elements such as iron, cobalt, nickel, chromium, manganese, or a few rare earth metals. This has led to the tacit assumption that no ferromagnetism could occur in an intermetallic compound unless it contained at least one strongly paramagnetic element.

Zirconium zinc becomes ferromagnetic below 35 K. Its ferromagnetic characteristics are similar to and of the same order of magnitude as those exhibited by conventional ferrites at room temperatures. Discovery of these properties provides scientists with a powerful new tool for the study of the fundamental characteristics of magnetism and magnetic materials.



SAMPLES of zirconium zinc are adjusted by B. T. Matthias of Bell Telephone Laboratories preparatory to measuring the magnetic properties of this compound at low temperatures.

Method Developed for Measuring Magnetic Forces

A method for measuring the magnetic forces that originate inside the earth and in outer space has been perfected by scientists T. L. Skillman of the U. S. Department of Commerce's Coast and Geodetic Survey and Dr. P. L. Bender of the National Bureau of Standards. Admiral H. A. Karo, director of the Survey, predicted that the development would provide scientists with magnetometers (instruments for measuring magnetism) far more precise and compact than those now available.

A beam of light is sent through a tube containing a small quantity of vaporized rubidium (one of the alkali metals). The manner in which the light is absorbed indicates the strength of the magnetic forces. The explanation is that the absorption of light depends on the spinning of the electrons in the rubidium molecule, and the spin in turn is controlled by the magnetic forces, or field.

Admiral Karo feels that "instruments embodying the principle will be simple, highly miniaturized, and capable of measuring very small magnetic fields—perhaps one billionth of the magnetic force developed by the motor that runs an apartment house elevator. They will be suitable for use in rockets and satellites. . . . A question to which science wants to answer is whether the moon has a magnetic field. It is believed that if there is such a field, it is fantastically weak. The rubidium mangetometer will be capable of measuring forces not otherwise detectable. Better understanding of the magnetism in outer space will help science toward solution of basic questions concerning the origin of the universe."

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Atomic Nucleus

To the Editor:

A recent article "What Holds the Atomic Nucleus Together?" (*Electrical Engineering*, July 1958, Of Current Interest department, pp. 659-60) reported on the thesis of Dr. J. J. Grebe, constructing a period table of the subatomic particles. His concept is a great step forward, although it does not reconcile the field and quantum theories. His concept has plus and minus electrons, which is still a paradox. A detailed study of these two particles should show that their physical properties can lead to the behavior of plus or minus and is a development of a still more fundamental property of the universe.

Sincerely,

W. B. MILLER (AM '49)

(Electrical Engineer, Consolidated Edison, Houston, Texas.)

USSR EE Education and Research

To the Editor:

British friends have pointed out to us that in our article on "Electrical Engineering Education and Research in the USSR, Part I—Education" (*Electrical Engineering*, May 1958, pp. 384-90), we omitted to mention an important British contribution to this subject[1]. The British report on "Engineering Education in the Soviet Union" was issued as a pamphlet in February 1957, but apparently was not given wide distribution in the United States. In fact, it was not available in our Pittsfield Library. It is hoped that it will be published soon in the *Proceedings of the Institution of Electrical Engineers* so that it may receive the attention which this thorough study deserves.

The British report is broader than ours in that it considers Soviet engineering education in general and compares it to British engineering education. Its data and conclusions are in good agreement with those of our paper.

We would like to take this occasion to point out that since our paper was written, an excellent book[2] has been published on scientific and technical education in the USSR.

P. A. ABETTI (M '55)
G. F. LINCKS (F '54)

(General Electric Company, Pittsfield, Mass.)

References

1. Engineering Education in the Soviet Union, report of a team of engineers who visited the Soviet Union in the Autumn of 1956. Publication #2308, February 1957, to be republished in the *Proceedings of the Institution of Electrical Engineers*, Part A.

2. Soviet Education for Science and Technology (book), A. G. Korol. Technology Press of the Massachusetts Institute of Technology, Cambridge, Mass., 1957.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AUTOMATIC CONTROL: PRINCIPLES AND PRACTICE. By W. G. Holzbock. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1958. 258 pages, 6¼ by 9¼ inches, bound. $7.50. The book discusses the dynamic behavior of control systems, including static requirements and adjustments for peak performance; gives a detailed description of electrical and mechanical components such as measuring elements, controllers, and control valves; and describes various control systems and their specific applications. The approach is in terms of practical concepts rather than in mathematical terms.

AUTOMATIC CONTROL TECHNOLOGY. Published by Instruments Publishing Company, 845 Ridge Ave., Pittsburgh 12, Pa., 1957. 483 pages, 8½ by 11¾ inches, bound. $25. This book contains papers delivered at a symposium held at Heidelberg, West Germany, in 1956 by the VDI/VDE Fachgruppe Regelungstechnik. Among the aspects treated are: combining theory and practice by representation and technique, technology of controlling devices, multiple loop controls, linear methods in feedback control, evaluation of nonlinear and discontinuous controls, statistical methods, computers in feedback control, control of steam generators, and industrial controls. Most of the papers are in English or German with German translations of the Russian papers included.

AUTOMATIC PROCESS CONTROL. By D. P. Eckman. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 368 pages, 6 by 9¼ inches, bound. $9. Automatic control principles are presented with emphasis on block diagrams and frequency techniques in process control. Beginning with process and controller characteristics, the book continues with the closed loop in automatic control, measuring and controlling elements, process instrumentation, sinusoidal analysis, and stability analysis.

BASIC ELECTRICITY FOR COMMUNICATIONS. By W. H. Timbie. Second edition, revised by F. J. Ricker. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 538 pages, 5¾ by 8¾ inches, bound. $6.25. This revision of a well-known text contains new material on metallic rectifiers, crystal diodes, transistors, the application of thyratrons to controlled rectifiers, industrial applications of gaseous tubes, and semiconductors. The material on circuit analysis has been rewritten to conform to American Standards.

CIRCUIT ANALYSIS OF TRANSMISSION LINES. By J. L. Stewart. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 186 pages, 6 by 9¼ inches, bound. $5.50. This publication presents an analytical approach to transmission lines with special attention given to radio frequencies and measurements. Simple transients, including application of transient operational methods; matching devices; the design of resonators and transmission cavities; the standing wave ratio; and the principles and applications of the Smith chart are discussed.

GASENTLADUNGSRÖHREN IN DER NACHRICHTENTECHNIK. (Nachrichtentechnische Fachberichte Bd. 9) Published by Friedrich Vieweg, Braunschweig, West Germany, 1957. 62 pages, 8¼ by 11½ inches, paper. 8.50 DM. This pamphlet contains a group of 12 technical reports on gas discharge tubes in communications engineering. Dealing mainly with cold-cathode tubes, the several reports cover new developments, breakdown characteristics, deionization time, ignition sensitivity and ignition delay, irregular oscillations and their elimination, and fundamental circuits.

A HISTORY OF TECHNOLOGY. Volume IV: The Industrial Revolution. Edited by Charles Singer and others. Oxford University Press, 417 Fifth Ave., New York 16, N.Y., 1958. 728 pages, 7¼ by 10 inches, bound. $26.90 A detailed account of the rise of modern industrialism is given in which six aspects are discussed: primary production, forms of energy, manufacture, static engineering, communications, and the scientific basis of technology. The volume is superbly printed and illustrated.

PRINCIPLES OF ELECTRONIC INSTRUMENTS. By G. R. Partridge. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1958. 393 pages, 6¼ by 9¼ inches, bound. $11. The first part of the book deals with instruments to measure electrical quantities by electronic methods. The second part discusses nonelectrical measurements by electronic instruments, such as velocity, time, sound, light, pressure and temperature, and radioactivity. Emphasis is placed on the circuits of instruments rather than their use, and on circuits designed to operate at relatively low frequencies.

THEORIE DER RELAISSYSTEME DER AUTOMATISCHEN REGELUNG. By J. S. Zypkin. R. Oldenbourg, Munich, West Germany, 1958. 472 pages, 6½ by 9½ inches, bound. 52 DM. A full description and analysis of relay systems for automatic control is presented. The types are classified and expressed mathematically. System stability under various conditions is discussed, characteristic oscillations and forced vibrations are treated, and optimum operating conditions are established. A thorough theoretical treatment of servomechanism fundamentals, this is translated from a Russian book published in 1955.

THE WEATHER CONDITIONED HOUSE. By Groff Conklin. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1958. 238 pages, 8¼ by 11¼ inches, bound. $14.75. An integrated approach to the factors affecting the house in its environment is given. Among those factors considered are general environment, climate, cold weather condensation, hot climate design, heating and cooling equipment, acoustical problems, and materials deterioration. Features of the volume are its photographs and the liberal use of tabular matter.

RECENT ADVANCES IN THE ENGINEERING SCIENCES: THEIR IMPACT ON ENGINEERING EDUCATION. Published by the McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 257 pages, 6¼ by 9¼ inches, bound. $4.75. This book surveys the educational implications of a number of expanding areas including automation and automatic control; operations research and systems engineering; thermodynamics; mass, momentum, and heat transfer; nuclear engineering; solid-state physics and engineering materials; and computer development and applications. The book is a report of the proceedings of the Conference on Science and Technology for Deans of Engineering, held at Purdue University in September 1957.

SCIENTIFIC PROGRAMMING IN BUSINESS AND INDUSTRY. By Andrew Vazsonyi. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 474 pages, 6¼ by 9¼ inches bound. $13.50. The author attempts to present the technique of scientific programming in terms of a mathematical language understandable to businessmen. An extensive review of the fundamentals of linear programming is given, including the simplex method, the dual theorem, geometry, convex and dynamic programming, and the elements of the theory of games. Specific applications discussed are transportation allocation, and production and inventory control.

SOLID STATE PHYSICS, VOLUME 5. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., 111 Fifth Ave., New York 3, N.Y., 1957. 455 pages, 6¼ by 9¼ inches, bound. $11. The present volume deals with the following five topics: (1) galvanomagnetic and thermomagnetic effects in metals; (2) luminescence in solids; (3) space groups and their representations; (4) shallow impurity states in silicon and germanium; and (5) quadrupole effects in nuclear magnetic resonance studies of solids. The numerous footnote references are indexed by authors and there is a subject index.

TECHNOLOGY OF INSTRUMENTATION. By E. B. Pearson. D. Van Nostrand Company, Inc. 120 Alexander St., Princeton, N.J., 1958. 202 pages, 5¾ by 8¾ inches, bound. $4.75. The basic principles of measurement by means of an instrument with moving parts are studied first, along with the parameters determining its static and dynamic accuracy. Servomechanisms and methods for improving their performance, the different ways of instrumenting position control systems in practice, and the problem of stability are then discussed.

A COMPREHENSIVE BIBLIOGRAPHY ON OPERATIONS RESEARCH. By the Operations Research Group, Case Institute of Technology. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 188 pages, 8½ by 11½ inches, bound. $6.50. A listing of 3,000 books, articles, reports, and proceedings intended for operations researchers is contained in this volume. Material closely related to this field is included. An alphabetical index to all of the citations is followed by bibliographies dealing with special fields of interest such as sequencing, theory, site location, and layout. The main bibliography covers references through 1956; a supplement contains titles published in 1957.

CONFERENCE ON EXTREMELY HIGH TEMPERATURES. Edited by Heinz Fischer and L. C. Mansur. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 258 pages, 8½ by 11¼ inches, bound. $9.75. Representing a summary of the knowledge underlying commercial or usable thermonuclear reactions, the book places particular emphasis on high temperatures as they relate to the propulsion fields. It covers the production of extremely high temperatures, methods of temperature measurement such as optical radiation, plasma analysis, and applications. The conference, held in 1958, was sponsored by the Electronics Research Directorate, U.S. Air Force Cambridge Research Center.

CREATIVENESS FOR ENGINEERS. By D. S. Pearson. Published by the author, Pennsylvania State University, University Park, Pa., 1958. 122 pages, 5¼ by 8¼ inches, bound. $3.75. The book consists of two parts, the first of which discusses a philosophy to stimulate creativeness and to motivate the potentially creative person; the second part deals with a creative approach aimed at producing a more effective reaction between the individual and his effort. Appendixes provide means for practical application of these principles.

EIA CONFERENCE ON AUTOMATION SYSTEMS FOR BUSINESS AND INDUSTRY, PROCEEDINGS. Published by Engineering Publishers, GPO Box 1151, New York 1, N.Y., 1958. 180 pages, 6¼ by 9¼ inches, bound. $5. This collection of papers deals with automation within and outside the electronics industry; and with the economic, educational, and social aspects of automation. The conference was sponsored by the Engineering Department of the Electronic Industries Association (EIA).

EINFÜHRUNG IN DIE MIKROWELLEN-ELEKTRONIK. (Part II: Lauffeldröhren.) By W. Kleen and K. Pöschl. S. Hirzel Verlag, Stuttgart, West Germany, 1958. 192 pages, 6¼ by 9¼ inches, bound. 28 DM. This treatise on traveling-wave tubes is based on the personal experience of the authors as well as on an extensive survey of the literature. The emphasis is on the technically important tube types although the general field is covered. Special topics dealt with include noise problems, backward-wave oscillators, circuits and wave structures, use of helical structures, and electron-beam focussing with magnetic fields.

ELECTRIC LIFTS. By R. S. Phillips. Fourth edition. Sir Isaac Pitman & Sons, Ltd., London, England, 1958. 411 pages, 5¾ by 8¾ inches, bound. 63s. Various aspects of design and installation of elevators are covered, including drives, roping systems, motors, variable voltage equipment, brakes, gearing, cars and guides, gates and doors, floor leveling; as well as control systems. In this edition, new illustrations are given for more recent equipment and the text has been rewritten to conform with recent practice.

ELECTRICITY IN AGRICULTURAL ENGINEERING. By T. E. Hienton and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 393 pages, 5¾ by 8¾ inches, bound. $7.75. Covering a wide variety of applications of electrical energy to agricultural practice, the book discusses the fundamentals of electric circuits, and gives particular attention to the electric motor including wiring requirements, controls, and protective devices necessary for proper installation and operation. Several chapters are devoted to the effect of electromagnetic radiation on agricultural products, including visible, ultraviolet, and infrared radiation.

ENGINEERING ECONOMY. By C. E. Bullinger. Third edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 379 pages, 6¼ by 9¼ inches, bound. $7. The publication deals with the various stages of planning from the inception of an idea to its development and design phases, including the design and operation of a factory to produce the product. This edition brings cost data up to date and introduces new operations-research procedures, particularly the concept of "models" and "criteria." The effect of state and Federal taxes on engineering projects is treated for the first time.

FINITE QUEUING TABLES. By L. G. Peck and R. N. Hazelwood. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 210 pages, 8¾ by 11¼ inches, bound. $8.50. The tables provided in this book are useful in the solution of queuing problems such as communication channel requirements for finite populations, machine loading determinations, and estimating equipment and manpower requirements. A preface gives information and examples illustrating the use of the tables in specific applications. This is the second volume in the series "Publications in Operations Research," sponsored by the Operations Research Society of America.

FOUNDATIONS OF INFORMATION THEORY. By Amiel Feinstein. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 137 pages, 6¼ by 9¼ inches, bound. $6.50. An analysis of the mathematical theory of information is presented. The author discusses the discrete channel with and without memory, the coding theorem for discrete channels without memory, the semi-continuous channel without memory, and the binary symmetric channel.

PRINCIPLES OF NOISE. By J. J. Freeman. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 299 pages, 6 by 9¼ inches, bound. $9.25. Covered in this book are such areas as probability, stationary random processes, physical sources of noise, equivalent noise generators, noise factor, measurement of a direct voltage, Gaussian random processes, the detection of alternating waveforms, and target noise.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

NUCLEAR ENERGY AND THE U.S. FUEL ECONOMY, 1955-1980. By P. D. Teitelbaum, this report is part of the series on Productive Uses of Nuclear Energy of the National Planning Association, Washington, D. C. The primary task of this report was to assess the aggregate effect of nuclear energy's introduction on the nation's total fuel and energy budget over the next generation. The six chapters of the report are: introduction; prospective energy prices, 1955-1980; projections of energy demand, 1955-1980; the competitive entry of nuclear energy, 1955-1980; economic implications of the projections; and summary of conclusions and of their implications for energy policy. There are 10 appendixes. The report may be ordered, at $3, from the National Planning Association, 1606 New Hampshire Ave., N.W., Washington 9, D. C.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint of a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 20 W 39 St., New York 18, N. Y.

TABLES OF TRANSPORT INTEGRALS. Modern theories of the transport properties of solids have progressed to the point where quantitative comparisons can be made between theory and the results of carefully controlled experiments. Transport integrals of the form tabulated occur quite frequently in the theories, especially for electrical resistance, thermal conductivity, and specific heat. These tables were prepared by members of the Properties of Materials Section of the Cryogenic Engineering Division, National Bureau of Standards, Boulder, Colo. Copies of the tables, NBS Circular 595, may be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 40¢.

ATOMICS & NUCLEAR ENERGY. This British publication is a monthly journal of nuclear engineering, the employment of radioactive materials, and the practical applications of nuclear research. Numerous articles by the world's leading authorities on every aspect of this subject are published in this journal, fully illustrated with photographs, diagrams, and flow sheets. Subscription rates, which have been reduced, are now $12 for one year, $30 for three years. Orders for subscriptions should be sent to Leonard Hill Technical Group, Eden St., London, N. W. 1, England.

AMERICAN STANDARDS ASSOCIATION. A revision of American Standard Y10.4, Letter Symbols for Heat and Thermodynamics, has been approved by the American Standards Association (ASA) and published by The American Society of Mechanical Engineers (ASME). Replacing an earlier standard issued in 1943, the extensive revision incorporates many significant changes and new viewpoints. Particular emphasis has been given to the breadth of the field so that accepted practice in fundamentals established by the chemist and physicist, as well as in all fields of engineering, is fully represented. The new standard may be obtained, at $1.50, from ASA, 70 E. 45th St., New York 17, N. Y., or from ASME, 29 W. 39th St., New York 18, N. Y.

OTS REPORTS. Three reports of electronics research for the Armed Forces have been released for industry use through the Office of Technical Services (OTS), U.S. Department of Commerce. The first, "A Solid-State Commutating and Pulse-Width Encoding Circuit," *PB 131486*, by W. H. Lucke, Naval Research Laboratory, 75¢, describes the development of a new transistorized commutator-encoder. The second report was prepared by W. E. Hauth, Jr., and R. E. Vanderhaar, International Resistance Co., for Wright Air Development Center. Called "Research and Development of High Temperature, Radiation Resistant Fixed Resistors," *PB 131655*, it reviews a study of the high-temperature resistivity of ceramics, and is available at $1. "A Comparison of Silicon and Germanium Low-Power Audio Alloy Transistors," *PB 131364*, by J. Mandelkorn, Evans Signal Laboratory for Signal Corps, U.S. Army, 75¢ is the third report and describes a comparative study of silicon and germanium transistors. All three reports are available from OTS, U. S. Department of Commerce, Washington 25, D. C.

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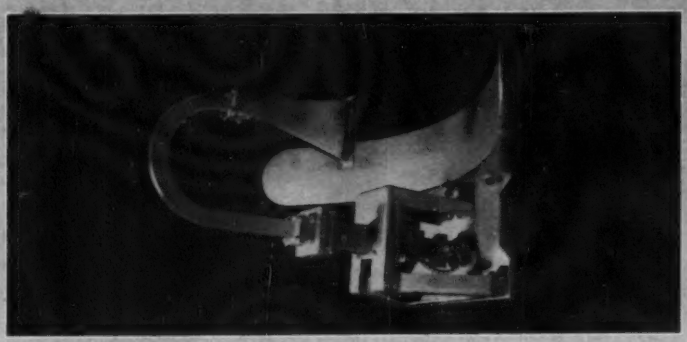
THE ENGINEERING INDUSTRIES IN EUROPE. Published by the Organisation for European Economic Co-operation (OEEC), this report forms part of the "4th Year" of a series of OEEC publications on the situation in the economic sectors. It is the second report prepared by the Machinery Committee and dealing with the engineering industries. The previous report was published in May 1956. Contents include a summary and conclusions, and four major subdivisions: the supply of engineering products, the demand for engineering products, international trade, and some aspects of the structure of the engineering industries. A statistical supplement of trends in economic sectors is included. The booklet is available through the OEEC Publications Office, 1346 Connecticut Ave., N.W., Washington 6, D. C. Price $2.

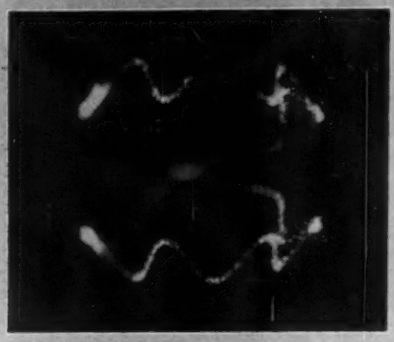
PROPOSED AMENDMENTS OF THE 1956 NATIONAL ELECTRICAL CODE. Important revisions proposed for the National Electrical Code in its 1959 edition have just been released by the National Fire Protection Association (NFPA). Panel reports, co-ordinated through the Correlating Committee of the NFPA Electrical Code Committee, are now available for study and comment by the electrical industry. One of the most significant proposals is to make effective the requirement for installation of fuseholders of the Type S design, for use with fuses of 30 amperes or less. This would delete the suspension of Section 2452 now in force. The effective date for the required installation of fuseholders of the Type S design would be set for January 1, 1961. A proposed change of language in the code section dealing with receptacle outlets in residences, Section 2124.b., is also of widespread interest. Now calling for an outlet every 12 linear feet, the section would be revised to require that outlets be installed so that no point along the floor line in any usable wall space is more than six feet, measured horizontally, from an outlet. The change of language is designed to clear up possible misinterpretation of the requirements. Another revision would change Section 2115.b. to require a minimum of two 20-ampere receptacle branch circuits for the small appliance load in kitchen, laundry, pantry, dining room, and breakfast room. The present requirement is for one such circuit. Industry comment and recommendations should be made to the chairman of the National Electrical Code Committee as listed in the NFPA publication. Copies of the proposed amendments, NFPA No. 70, 140 pages, are available at $1.75 from NFPA, 60 Batterymarch St., Boston 10, Mass.

IGY DATA REPORT SERIES. Three series of reports covering data obtained in the U.S. IGY program have been announced by the National Academy of Sciences (NAS). The reports are published by World Data Center A in the United States. The three series are: (1) IGY General Report Series, (2) IGY Satellite Report Series, and (3) IGY Rocket Report Series. Each report in the three series is priced at $1, postage prepaid. Orders should be addressed to the Publications Office, NAS, Washington 25, D. C. Remittances must accompany orders of $1 or less; UNESCO book coupons are accepted. Checks and money orders should be made payable to the NAS. Standing orders can be placed for all titles published in the three series.

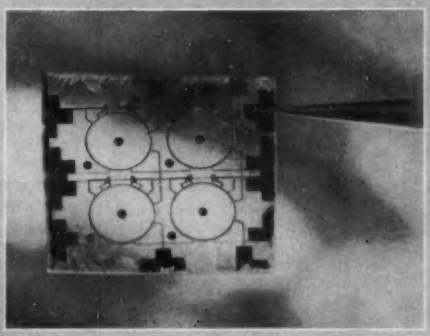
NATIONAL SAFETY COUNCIL PUBLICATIONS. The National Safety Council (NSF) has announced the availability of four new publications dealing with fire hazards and accident prevention. The first of these, the 1958 edition of "Accident Facts," contains facts and figures on industrial, traffic, home, farm, and school accidents. An off-the-job pamphlet, "Getting on—Safely," emphasizes the special environmental aids and personal practices that can help prevent accidents to elderly persons. The 2nd edition of the "Handbook of Accident Prevention" contains much new material on occupational safety, including a description of radioactive hazards and ways to protect against them. An accordion-fold pamphlet, "Don't Be Alarmed," gives the latest information and advice about fire protection and prevention. Further information on all four publications and their quantity prices may be obtained from NSF, 425 N. Michigan Ave., Chicago 11, Ill.



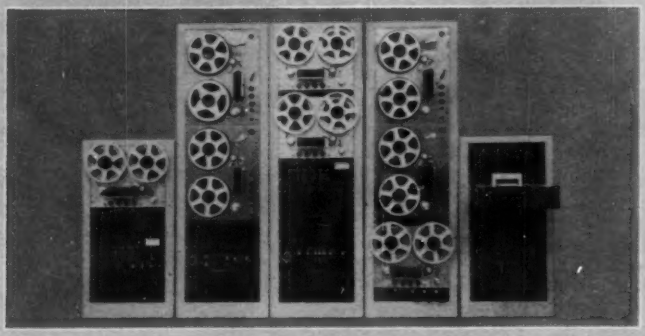
Horn fed parabolic reflector antenna for airborne applications.



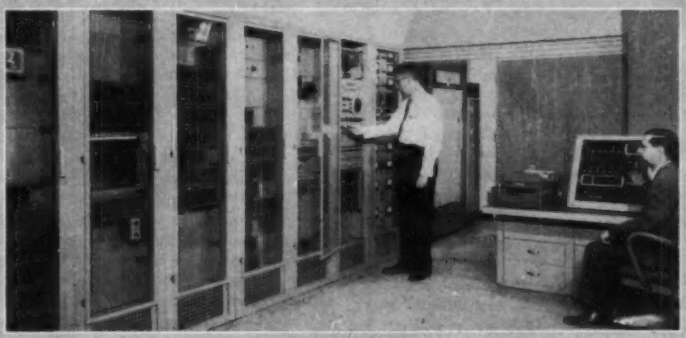
Charged aluminum particle suspended and controlled in a vacuum chamber by an oscillating electric field.



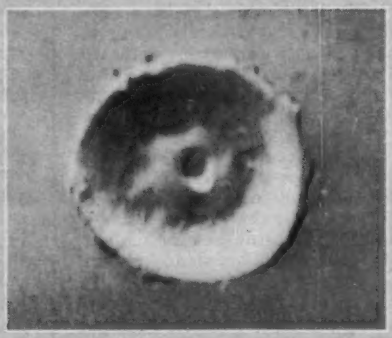
The Persistor gives promise of cryogenic computer memories with a capacity of 1,000,000 bits per cubic foot and access times of 1/30 microsecond.



Ground based data handling equipment for processing analog and digital reconnaissance information.



Data conversion system for digitizing and processing telemetered missile test data.



Electron micrograph of impact produced on aluminum coated glass by a 1 micron diameter particle traveling at 7,000 feet per second.

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent research, development, and manufacturing activities at Ramo-Wooldridge. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields:

- Digital Computers and Control Systems
- Communications and Navigation Systems
- Guided Missile Research and Development
- Infrared Systems
- Electronic Countermeasures
- Electronic Instrumentation and Test Equipment
- Basic Electronic and Aeronautical Research

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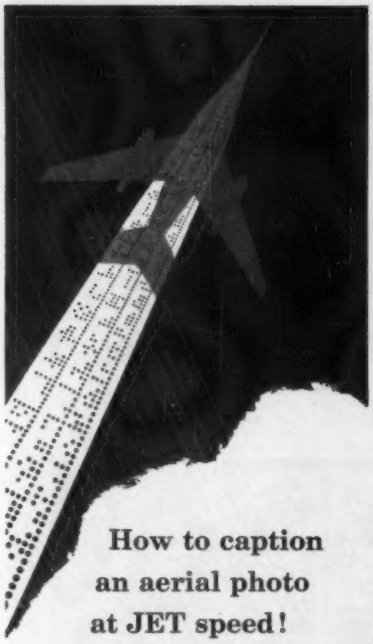

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Digital Data Recording Device, a new development of ITT Laboratories, makes this feat possible for the first time.

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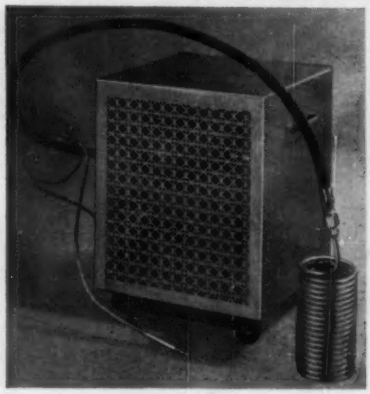
NEW PRODUCTS

Cold-Coil. A new device called Cold-Coil provides a refrigerated cooling coil which can be immersed in liquid or placed in a cabinet to create a cold chamber, improvised as needed. Self-contained and portable, the unit comprises a rolling cabinet housing the compressor aud thermostat, plus a 5-foot extension hose to the tinned copper Cold-Coil. The unit plugs into any 115-volt a-c outlet. It is simply rolled to the job, plugged in, and the Cold-Coil placed where needed. Advantages are numerous in a wide range



Courtesy Andrew Technical Supply Co.

of applications calling for temperature conditions below ambient. Extensive applications include tempering of film processing tanks, maintaining reduced temperatures in cold baths, auxiliary cold-tempering of conditioning cabinets, quick cooling of liquids without introducing additional liquid or ice, creation of cold fingers or traps as required in laboratory processes. Also, there are many other applications in laboratory work. Full data is available from Andrew Technical Supply Co., 7068 N. Clark St., Chicago 26, Ill.

Precision Punched Mica Available. Natural "muscovite" mica, a material with unusual dielectric and thermal properties, can now be obtained in a wide variety of forms and dimensions. Paper-thin shims, washers, as well as complex, multiholed, eyeletted fabrications and combinations with other materials are being produced for the electronics, instrument, and guided missile fields. Additional information on precision-punched mica and fabrications is available from Alan Long, Ford Radio & Mica Corporation, 536 63rd St., Brooklyn 20, N. Y.

Jumbo Nixie Indicator Tube. This 3-inch-diameter, all electronic in-line indicator, type BD-307, is designed to meet the needs of visual presentation at viewing distances of over 150 feet. Low power and rugged construction are additional features according to the manufacturer. The new Jumbo Nixie contains the numerals 0 through 9 and a common anode for circuit simplicity. Further information can be obtained by contacting Burroughs Corporation, Electronic Tube Division, Plainfield, N. J.

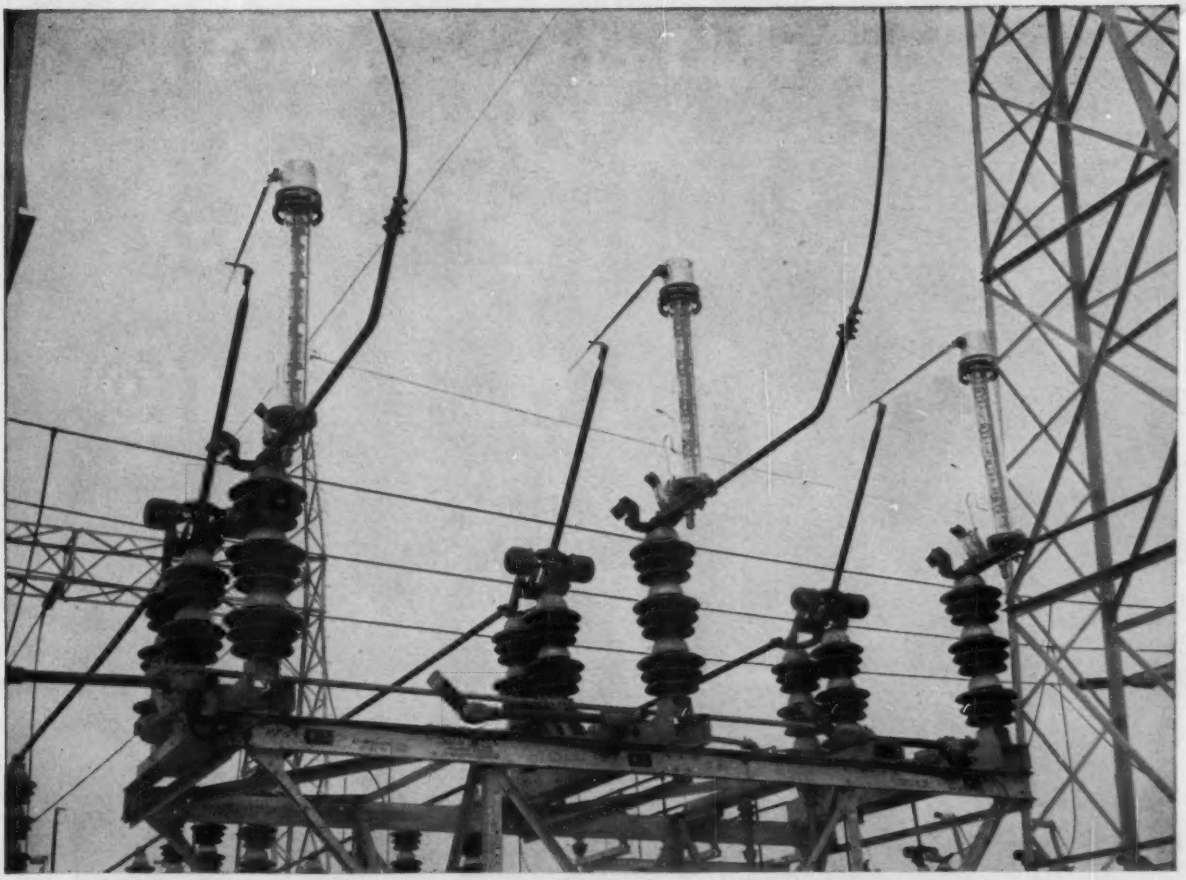
Three Solid Epoxy Resins. Designated D. E. R. *661*, *664*, and *667*, the resins will be used in coatings for appliances, auto body primers, cans, drums, tank cars, and for industrial maintenance. In addition, the manufacturer anticipates that the resins will be used in glass-reinforced laminates for aircraft structures, arhesives, and electrical printed circuits. For further information contact The Dow Chemical Company, Midland, Mich.

Cable Tester. Complex, branching circuits are simultaneously high potted, tested for continuity, and measured for leakage resistance between each circuit and all others by a cable tester. The new instrument has calibrated front panel controls that allow completely independent settings of all test parameters. Checking at a rate of 5 wires per second in automatic operation, the tester stops when a faulty circuit is found. Measurements are made on precision bridges which combine accuracy with fail-safe operation. For further information contact California Technical Industries division of Textron Inc., 1431 Old County Rd., Belmont, Calif.

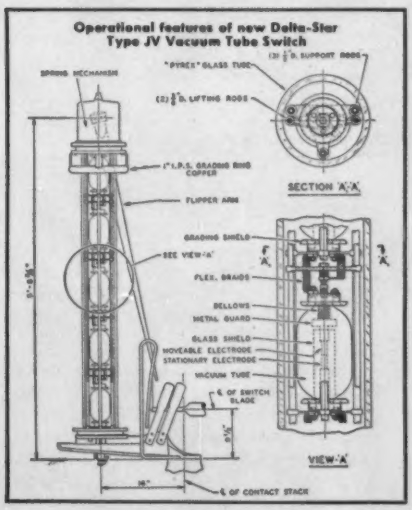
High-Temperature Service Brazing Alloy. A nickel-base brazing alloy containing chromium and phosphorous for high-temperature service is now available from Stainless Processing Division, Wall Colmonoy Corporation, 19345 John R St., Detroit 3, Mich. Designated Nicrobraz (registered trade mark) *50*, the brazing alloy is recommended for any application where high strength, minimum penetration of brazing alloy into base metal, and low neutron absorption is required. It is being used successfully in atomic reactor heat exchangers (in hot zone) and other thin-walled complex radiators. Other typical applications are honeycomb sandwich panels, thermocouples, and electrical harnesses.

Constant Force Brush Springs Resist Bounce. In the design of motors which power Master Vibrator self-contained concrete vibrators, the problem of vibration has been overcome by using laminated constant-force Neg'ator brush springs manufactured by the Hunter Spring Co., Maple and Spring Aves., Lansdale, Pa. Despite constant shortening of brushes from normal wear, and hence constant change of spring deflection, these spirally coiled band springs always exert the same force on the brushes. Thus, they present equal resistance to brush bounce at all times, and assure proper commutation despite the fact that the entire unit is designed to vibrate up to 15,000 times per minute with an amplitude of vibration of 1/16 inch.

(Continued on page 26A)



FOR INTERRUPTING HIGH LOAD AND CAPACITIVE CIRCUITS



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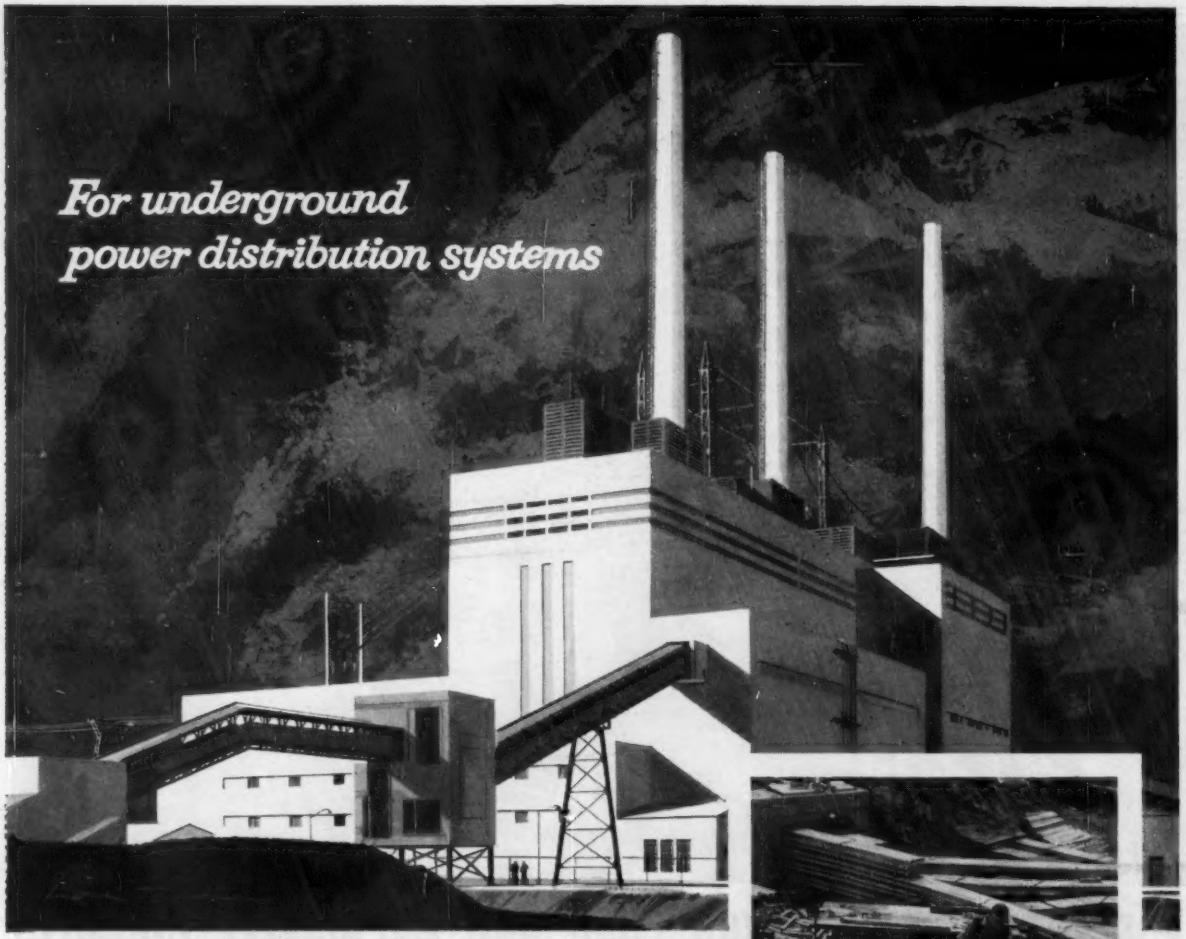

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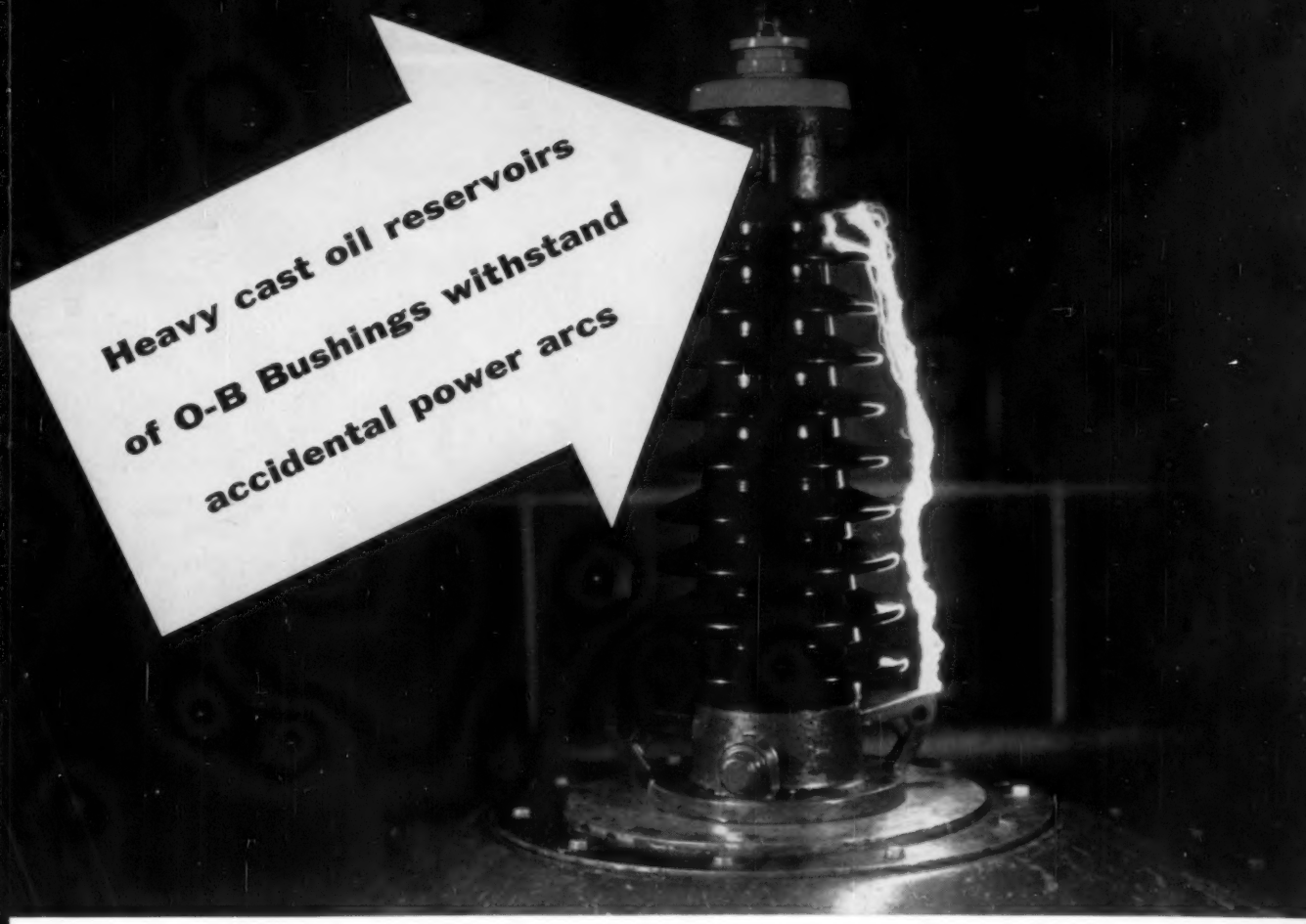


Why make a bushing's oil reservoir in the form of a heavy bronze casting? Isn't it wasteful? After building bushings this way for 50 years, maybe we just can't break with tradition.

Granted, 50 years' experience has a lot to do with it. On rare occasions, the reservoir may serve a special purpose. In the event of flashover, it is one terminal of a blazing power arc. This can burn a hole in a flimsy part, and the bushing is lost. Heavy cast bronze won't permit this -- it hasn't, so far as we know, in 50 years. The small extra cost involved is simply an investment in maximum safety and service.

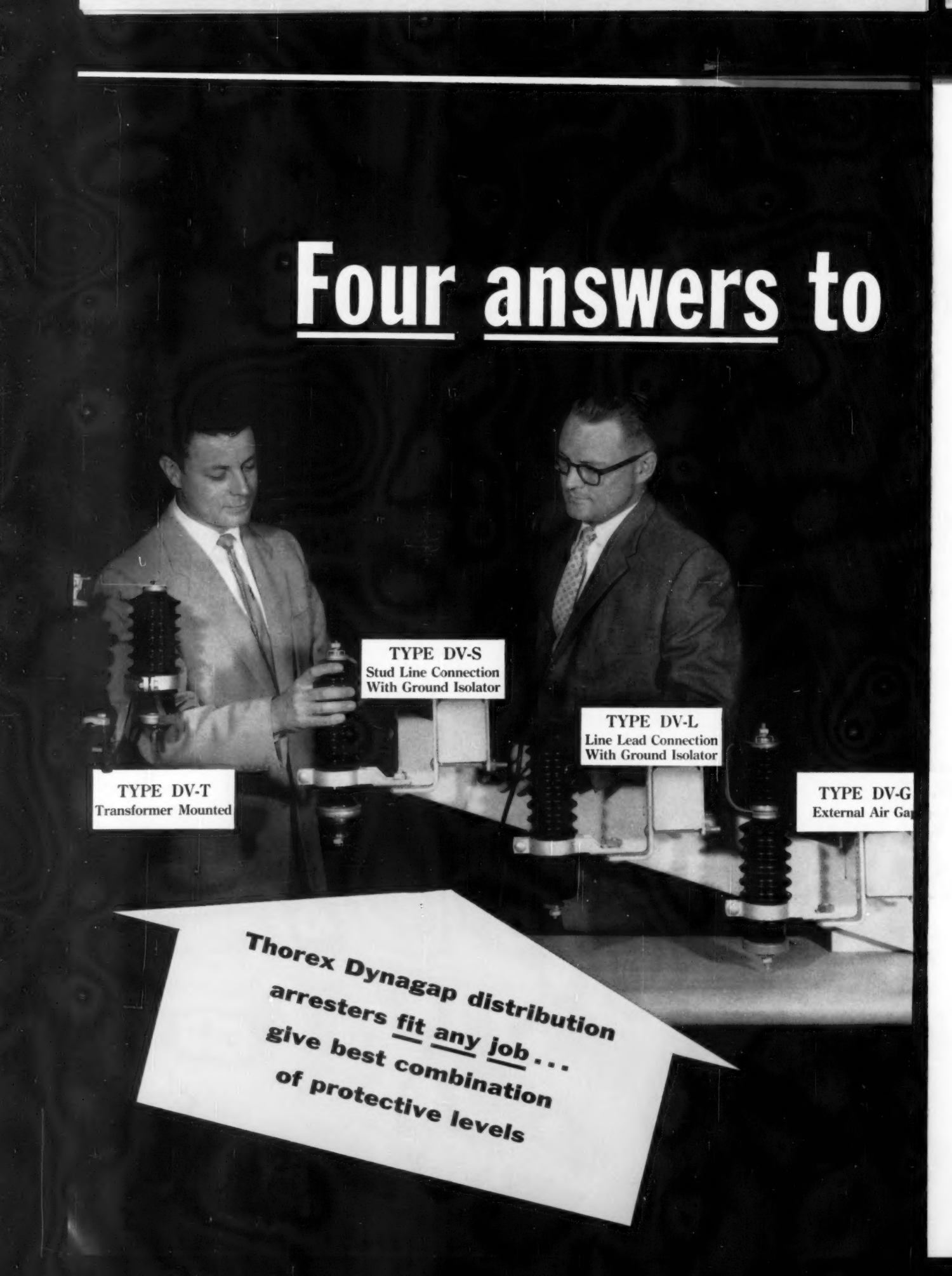
One of the intangibles you buy in modern O-B condenser bushings is mature knowledge of the business. This shows-up in all kinds of ways and places. It's "the extra value in the package."

Manufacturers of transformers and circuit breakers are glad to supply the bushing of your choice, *when you express that choice.* Make a point of asking for O-B bushings. It's very well worth the slight extra attention.

OHIO BRASS COMPANY, MANSFIELD, OHIO
Canadian Ohio Brass Co., Lt., Niagara Falls, Ont.

Ohio Brass

Four answers to



Thorex Dynagap distribution arresters fit any job . . . give best combination of protective levels

better lightning protection

Order them with your new transformers - - mount them on your crossarms - - specify automatic ground lead isolators - - use external or internal gaps - - choose your method of line connection - - there is a Thorex Dynagap lightning arrester built to fit every distribution job.

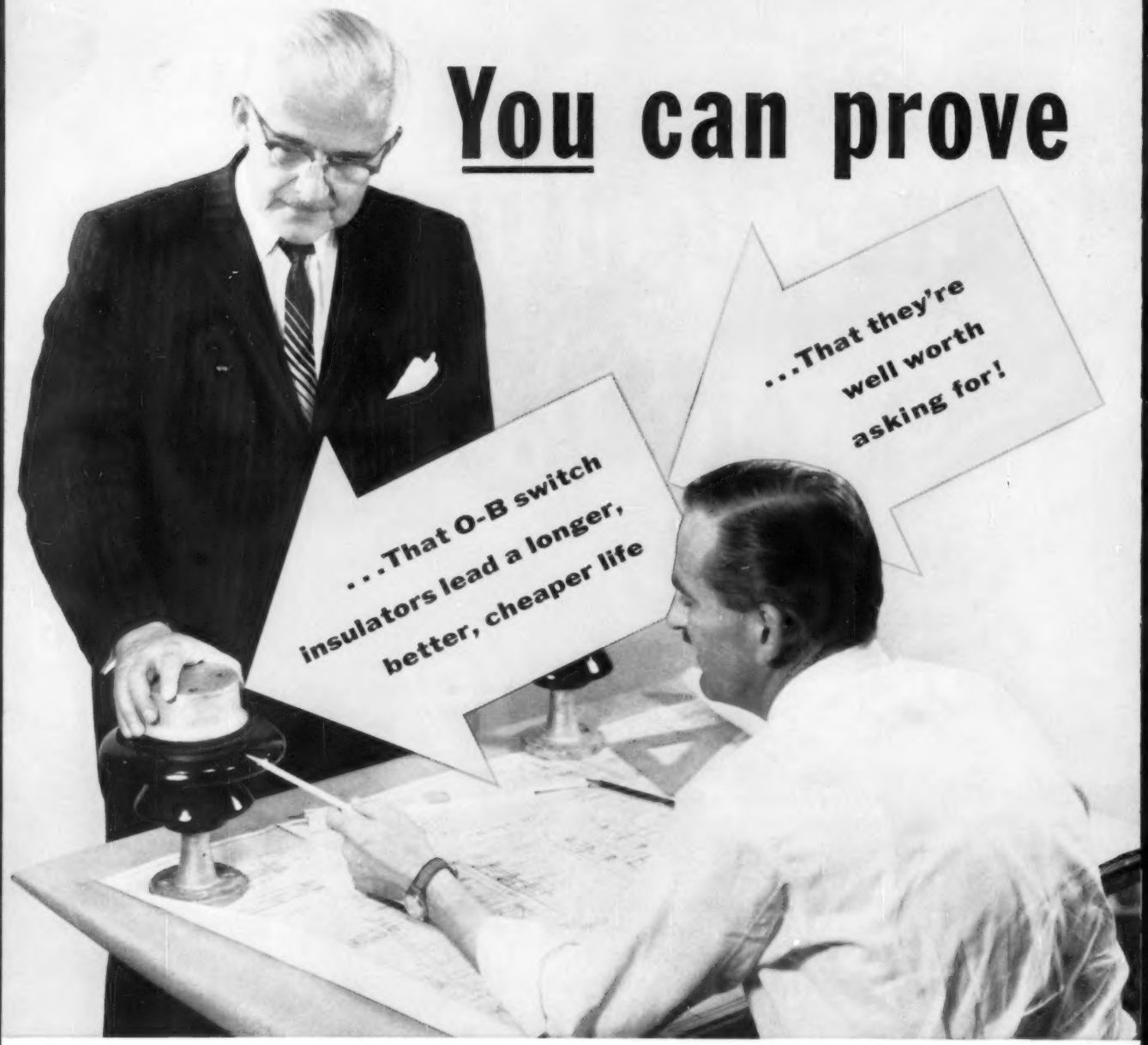
Inside each one is the remarkable new Dynagap element, identical in all grades of Thorex arresters; Distribution, Intermediate, and Station Class. Its compact size brings to the distribution field many protective factors once associated only with heavier-duty equipment, and a complete innovation in distribution construction.

For an entirely new order of distribution lightning protection install the Thorex Dynagap - - by any measure, the best in modern arrester design.

OHIO BRASS COMPANY, MANSFIELD, OHIO

Ohio Brass

You can prove



Standards *don't say* all switch insulators are alike -- neither does your experience. Some live longer than others, and give "better mileage" on your investment. Some have a history of little or no trouble; little or no maintenance expense.

Which ones? Look at your own records.

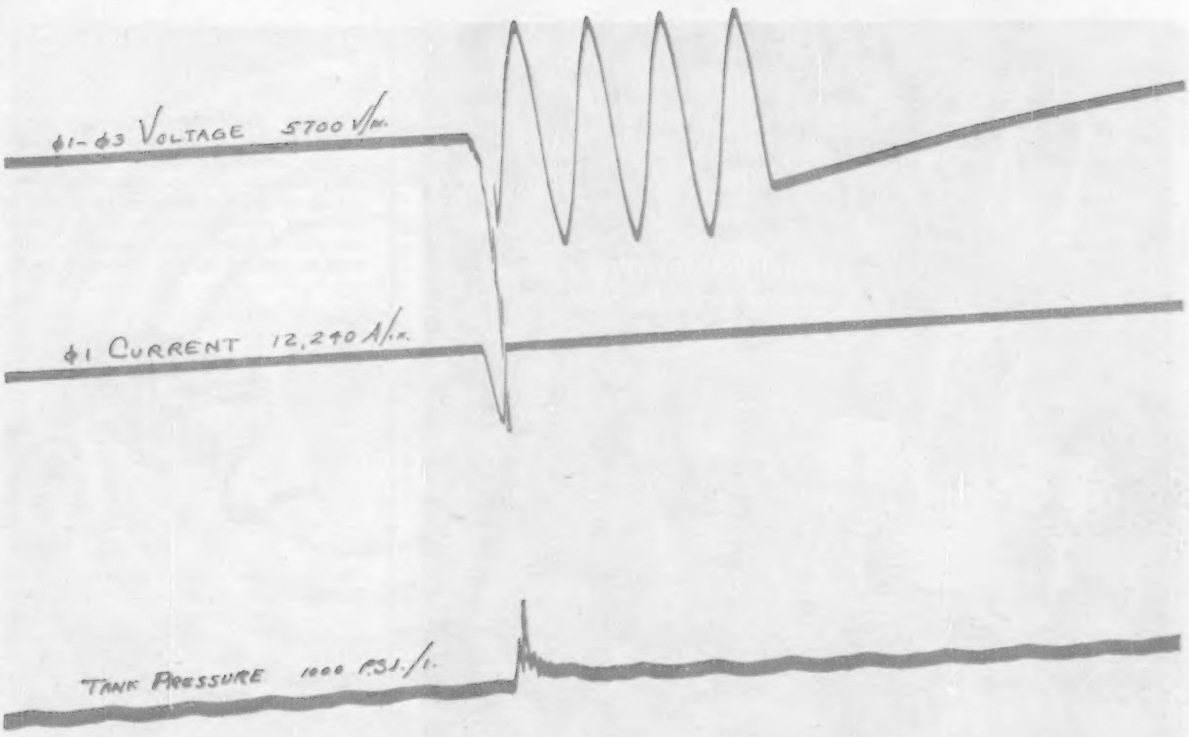
In your own files -- maybe your own handwriting -- and stated in your own terms, are facts that should contain an interesting story. You can see what insulators were installed, when, and the subsequent replacement record, and if your findings are typical, O-B will show a distinct advantage. Remember, this isn't *our* story, it's *yours!*

Switch manufacturers will gladly supply any make of insulator you choose. You need only *make that preference known.* By the simple act of asking for O-B insulators on your new switches, you will continue getting a bonus in performance that your own operating facts can prove is true.

OHIO BRASS COMPANY, MANSFIELD, OHIO
Canadian Ohio Brass Co., Ltd., Niagara Falls, Ont.

Ohio Brass

4910-H



TESTS SHOW

EXTRA

INTERRUPTING CAPACITY

FOR THE G&W FC42 OIL FUSE CUTOUT

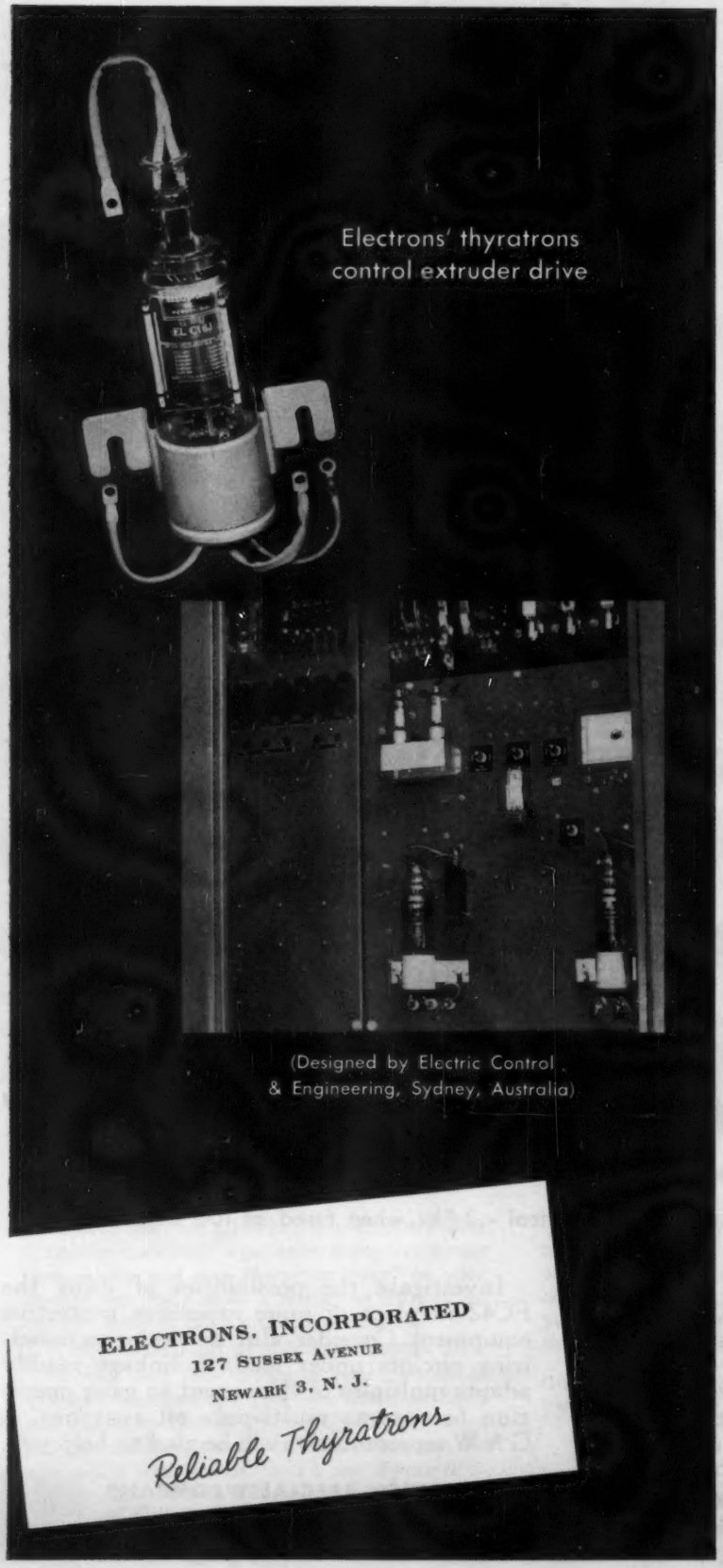
interrupting capactity 12,000 amps. asymmetrical - 2.5kv, 200 amps.

extra interrupting capacity 16,000 amps. asymmetrical - 2.5kv, when fused at 100 amperes or less

This cutout can be used where there is an available fault current of 16,000 amperes (asymmetrical) provided that a fuse link rated 100 amperes or less is used. The application rating of 16,000 amperes at 2,500 volts is made possible by the current-limiting action caused by the fuse melting before the current can reach peak value. The fuse melts in only a fraction of the first half of the cycle of fault current and limits the current to a relatively small value.

Investigate the possibilities of using the FC42 in place of more expensive protective equipment. Consider, also, its use for sectionalizing circuits under load. A linkage readily adapts multiples of the cutout to gang operation for use as multi-pole oil switches. A G & W representative will be glad to help you.

G&W ELECTRIC SPECIALTY COMPANY
3500 W. 127TH STREET • BLUE ISLAND • ILLINOIS
CANADIAN MFR.-POWERLITE DEVICES, LTD.-TORONTO, MONTREAL & VANCOUVER
C 581



New Products

(Continued from page 18A)

"T-Power" Radiophone. A mobile 2-way radiophone operating in 450-470-mc frequency band, featuring a transistorized power supply and an advanced unified chassis design, has been announced. The new unit provides greater reliability and operational benefits than possible before with equipment in this frequency range.

The equipment utilizes transistors in the power supply rather than the traditional mechanical vibrators and so fills out the Motorola T-Power radio line. For more information, write to Motorola Communications & Electronics, Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.

High-Voltage Rectifier Packages. By reducing many individual rectifiers to a single, hermetically sealed component, a new series of "packaged unit" rectifiers, now available, assure simplified circuit design and installation ease in high-voltage applications. These compact units minimize space problems while providing ratings from 1 millampere to 1 ampere and voltages as high as 30,000 volts. Circuit configurations for these units range from half-wave to 3-phase full wave. To fit specific applications, either silicon or selenium rectifiers may be used in their assembly. They are packaged in hermetically sealed, oil-filled housings and are operable in temperature ranges up to 150C. The units are designed to offer unusual compactness in such applications as airborne radar supplies, electrostatic precipitation, infrared, irradiation, and X-ray power supplies. Inquiries relating to higher ratings and other configurations of these rectifiers may be addressed to International Rectifier Corporation, Electronics Products Department, 1521 E. Grand Ave., El Segundo, Calif.

Stud Tightening with Electric Heat. Chromalox electric stud heaters provide the fast, even heat needed for shrink-tightening large studs and holding bolts. This insertion type heater finds many uses in the manufacturing, assembly, and servicing of steam pressure vessels, large presses, motors, or turbines—wherever maximum tightness is desirable. Write to the manufacturer, Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa. for leaflet *1244* which contains detailed product description, illustrations of how to use, and table of Chromalox stud heaters sizes, rating, and price.

(Continued on page 28A)

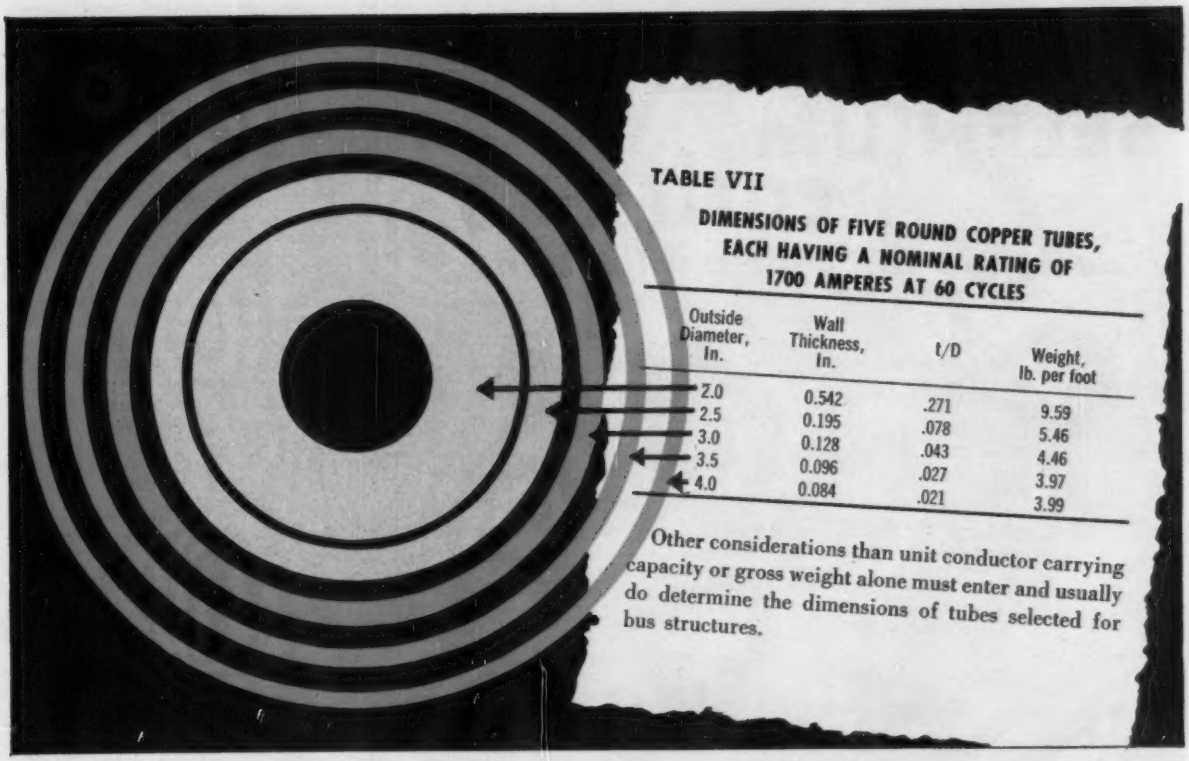


TABLE VII

DIMENSIONS OF FIVE ROUND COPPER TUBES, EACH HAVING A NOMINAL RATING OF 1700 AMPERES AT 60 CYCLES

Outside Diameter, In.	Wall Thickness, In.	t/D	Weight, lb. per foot
2.0	0.542	.271	9.59
2.5	0.195	.078	5.46
3.0	0.128	.043	4.46
3.5	0.096	.027	3.97
4.0	0.084	.021	3.99

Other considerations than unit conductor carrying capacity or gross weight alone must enter and usually do determine the dimensions of tubes selected for bus structures.

Reducing Bus Costs with Thin-Wall Tubes

Where mechanical requirements permit, bus costs can be cut through the use of tubular bus conductors with low wall-thickness-to-diameter ratios.

The chart above shows how the weight of metal purchased goes down as the t/D goes down for five round copper tubes of the same nominal current-carrying capacity.

What is true of round tubes is also true of other tubular bus shapes—low wall thickness giving decided electrical advantages.

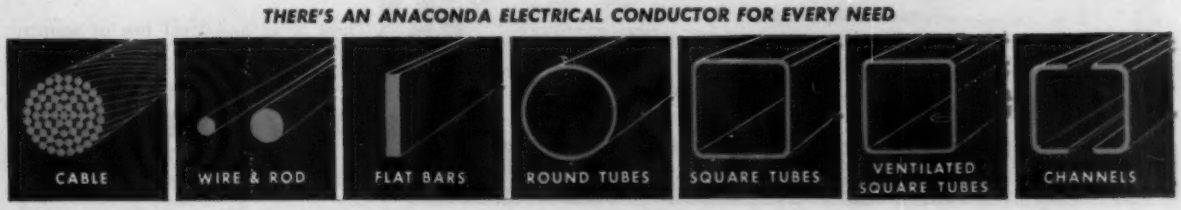
Round tubes in the standard pipe dimension, and thin-wall sizes also offer other advantages. You can utilize the great variety of stock sizes of supports, connectors, clamps, and other hardware in dealers' stocks.

For more complete information on the use of thin-wall tubes see the Sixth Edition of The American Brass Company's publication, "Anaconda Copper for Electrical Conductors." This 62-page booklet has a wealth of general information on the properties of electric conductors – plus convenient tables giving the electrical and mechanical properties of copper bus conductors for all the most commonly used sizes of the popular shapes. Much of the material has not heretofore been published.

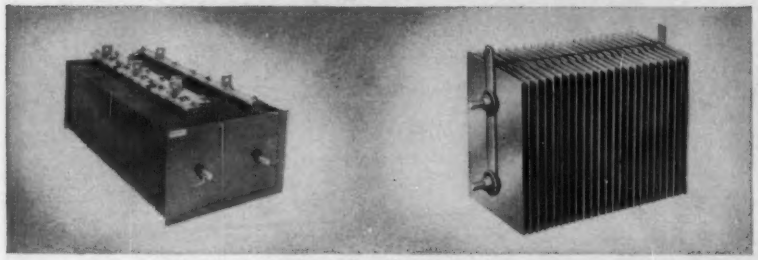
TECHNICAL SERVICE. The services of Anaconda specialists are available to help you in the solution of special problems involving the use of ANACONDA Bus Conductors. For such help—or for a copy of "Anaconda Copper for Electrical Conductors"—see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. 5699 Rev.

ANACONDA® COPPER CONDUCTORS

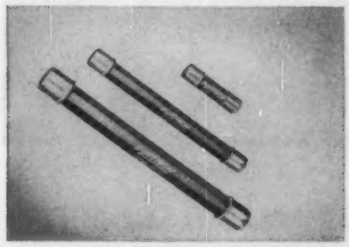
THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED



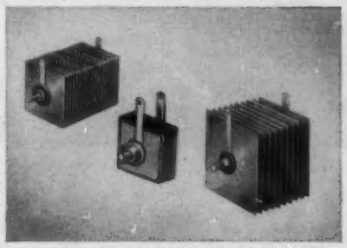
SYNTRON
SELENIUM RECTIFIERS
designed for your application



Industrial Power Rectifier Stacks — high efficiency, low maintenance. SYNTRON 12" x 16" cell is the largest cell size in the industry. Designed for arc welders, heavy d-c power supplies, etc.



Cartridge Rectifier Stacks — low current, high voltage. Maximum 20 milliamperes, maximum input 15,000 R.M.S. volts.



Commercial Rectifier Stacks — Designed for business machines, elevator controls, magnetic chucks, brakes, clutches, vibratory equipment,

—The widest range of cell sizes in the Industry

SYNTRON Selenium Rectifiers are manufactured under laboratory controlled conditions, assuring product uniformity.

SYNTRON Selenium Rectifiers are noted for these exceptional characteristics — low voltage drop, low leakage current, low temperature rise and cell uniformity for long stack life.

Let our application engineers make recommendations for all your rectifier needs.

Other SYNTRON Equipment
designed to increase production, cut production costs, improve products

Vibrators (bins, hoppers, chutes)
Vibratory Feeders
Vibratory Screens
Shaker Conveyors
Vibratory Elevator Feeders
Weigh Feeders
Packers and Jolters
Hopper Feeders
Lapping Machines

Rectifiers (Silicon and Selenium)
a-c to d-c Selenium Rectifier Units
Electric Heating Panels
Electric Heating Elements
Sinuated Wires
Shaft Seals
Electric Hammers
Concrete Vibrators
Paper Joggers

Our representatives will be glad to work with you in selecting the proper equipment for your operation.

Call your nearest Syntron representative.

For more information write for complete catalog . . Free

E 358

SYNTRON COMPANY
440 Lexington Avenue — Homer City, Penna.

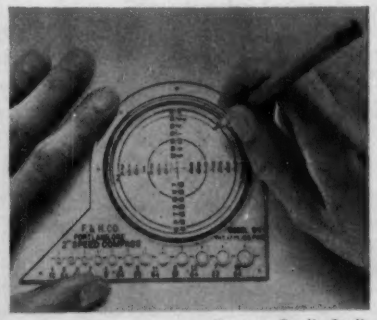
New Products

(*Continued from page 26A*)

Intermediate Radiant Heating Element. Peak emission of the new Infrasil quartz heating element is fixed at the 2.1 micron wave length band to increase operating efficiency for infrared applications. Uniform high-energy radiation of the Infrasil unit provides deep penetration for heating, baking, drying, cooking, pasteurizing, and other uses. Energy losses due to incandescence and convection by near- and far-infared are eliminated. The Infrasil element is immune to corrosion, chemically inert to most acids at high temperatures, and resists thermal shock and vibration. The fused quartz tube will withstand operating temperatures in excess of 2,000 F. Write to the manufacturer: Quartz Radiation Corp., 54 Summer Ave., Newark, N. J.

Flexible Lighting System. An improved lightweight and flexible 20-ampere Universal lighting system, designed for use in commercial and industrial lighting as well as for stores, store windows, showrooms, offices, and public buildings, is announced by BullDog Electric Products Company a Division of I-T-E Circuit Breaker Company, Detroit 32, Mich. This economical and versatile system is easily installed and supports, as well as feeds, the lighting fixtures. No supplementary fusing is required, according to M. P. Spurrell, director of sales of BullDog. Fixtures may be positioned at any spot throughout the entire system. Unique terminal and receptacle twistout plugs provide positive, safe connections in a matter of seconds anywhere along its length. Receptacle twistout plug has opening for two or three wire attachment plugs.

Two-inch Speed Template Compass. This new precision drafting instrument permits the draftsman to make perfect circles from ¼ inch to 2 inches in diameter by inserting pencil or pen in the desired hole and spinning around center.

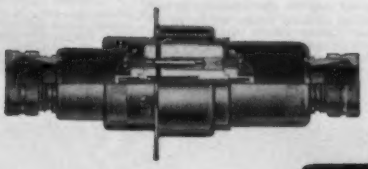


Courtesy Condit Studio

There is an additional row of template holes from 1/16 inch diameter to 15/64 inch, which affords the draftsman a choice of 69 diameters. For literature and price information on the 2-inch Speed Template Compass write to F. and H. Mfg. Co., 817 N. W. 23rd Ave., Portland 10, Oreg.

(*Continued on page 34A*)

IMPROVED TRIPLOC® CONNECTORS



Industry's most adaptable—most versatile general duty plug and receptacle line for power, control, electronic and thermocouple circuits in U/L circuit breaking ratings up to 20 amperes 250 volts, D.C., 460 volts, A.C.

Pyle-National's Triploc is the finest line of connectors on the market today, in its electrical rating and general application class. In the Triploc compact size and price range, no other connector can approach its rugged construction for industrial service . . . or equal the hundreds of optional shell assembly combinations possible with the standard 1 to 12 pole interchangeable and reversible contact inserts. Combinations up to 48 poles are easily assembled in enlarged shells which gang 2, 3 and 4 standard inserts. Water-tight shells also 2-wire and 3-wire fusible plugs are available.

New, Enlarged Wiring Space. Triploc's cadmium plated, pressed steel shells are of strong, low-weight design and provide ample wire terminating space for all inserts.

Self-Locking Triploc Plugs are available with automatic cord-strain release or with manual twist release only.

Wide Choice of Wire Terminals. Contact inserts are available with binding screw terminals—back wired, side wired, or pressure eyelet type; solder well type; crimp type.

Midget Triploc Round Prong Series is available in 2, 3 and 4-pole ratings of 20 amperes, 125 volts A.C.; 15 amperes, 125 volts D.C.; 10 amperes, 277 volts A.C.

SINCE 1897

THE PYLE-NATIONAL COMPANY

Sold nationally through authorized distributors. Write for bulletin 1252-B-C.

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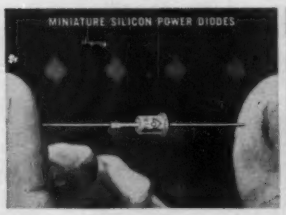
ELECTRONIC TYPES FOR INDUSTRIAL AND MILITARY APPLICATION

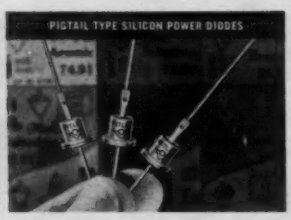
SILICON AND SELENIUM LOW CURRENT TYPES TO 1 AMP.

*SPECIAL MILITARY TYPES

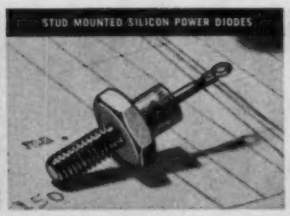
Special configurations and high reliability rectifiers for military applications may be obtained under our "Prescribed Reliability" Program. Address your inquiry to: Military Products Dept.



Ratings: 100 to 600 PIV, Up to 900 ma.
Specifically designed for missile and airborne equipment applications where miniaturization and reliability are prime factors. Hermetically sealed, all-welded, pigtail lead construction. Manufactured to meet the most rigid military requirements. Request **Bulletin SR-303**



Ratings: 50 to 600 volts PIV • 250 to 750 ma.
An extensive line of silicon power diodes for military and industrial applications featuring all-welded, hermetically sealed construction. All designed and manufactured to meet the most rigid military requirements. For information on types for your application **Contact Factory**



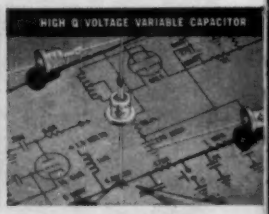
Ratings: 50 to 600 volts PIV • 400 ma. to 1 amp.
Industrial and military types including the 1N253, 1N254 and 1N255. Stud mounted, hermetically sealed, all-welded construction. Operating temperature range: –55°C to +150°C. Designed and manufactured to meet most rigid military specifications. **Bulletin SR-139C**

Ratings: 20 to 160 volts • 100μa to 11 ma.
Ideal components for bias supplies, sensit relays, computers etc. High resistance, megohms and higher at –10 volts). Excelle linear forward characteristics. Extremely sm low in cost. Encapsulated to resist adve environmental extremes. Specify **Bulletin SD-**

Ratings: From 100 ma. to 50 Amps.
Low forward voltage drop and low leakage characteristics make this series ideal for a wide variety of power applications. For details request **Bulletin C-439,** (26 volt cells); **Bulletin SR-160,** (45 to 52 volts per cell) and **Bulletin SR-152,** on high current density cells.

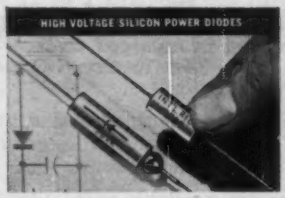
Ratings: 25 to 156 volts AC, 50 to 1,200 ma. DC
The widest range in the industry! Designed for Radio, Television, TV booster, UHF converter and experimental applications. Input ratings from 25 to 156 volts AC and up. DC output current 50 to 1,200 MA. Write for application information. **Bulletin ER-178-A**

Ratings: 400 PIV, up to 750 mA.
SD-800. A hermetically sealed, all-welded silicon junction rectifier offering maximum reliability in the high temperatures encountered in TV applications. Pigtail leads eliminate the need for brackets, blocks, etc., simplify installation. For complete data: **Contact Factory.**

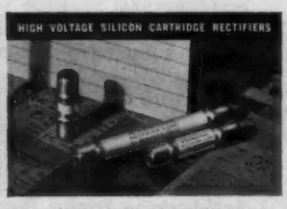


Ratings: Q of 1600, 200 PIV DC
Semicap's small size, light weight, high rel bility and low power requirements make ideal for automatic frequency control, f quency modulation oscillators and Hi networks. All-welded hermetically seal shock-proof housing. Request **Bulletin SR-2**

SILICON AND SELENIUM HIGH VOLTAGE TYPES



Rating: 600 to 2400 volts PIV • 100 to 125 ma.
Three types available. Hermetically sealed, pigtail construction. Style J rated at 600 to 1000 volts PIV at 125 ma. **Bulletin SR-138E** Styles K and L with PIV ratings from 600 to 2400 volts at 100 ma. dc output current are described in technical detail—**Bulletin SR-157.**



Ratings: 1500 to 16,6000 volts PIV @ 45 to 440 ma.
Especially suited for miniaturized military equipment where optimum reliability is a prime factor. Standard types for normal convection cooling and high current types for forced air or oil cooling. Hermetically sealed, metallized ceramic housing. Request **Bulletin SR-235**

Ratings: 20 to 20,000 volts • 0.2 to 195 ma.
Designed for long life and reliability in half-wave, voltage doubler, bridge, center-tap circuits, and 3-phase circuit types. Phenolic cartridges and hermetically sealed types available. Operating temperature range: –65°C to +100°C. For details specify **Bulletin H-2.**

Rating: 12,500 volts PIV at 5 Amps.
Illustrated above is a typical rectifier of vanced design produced by International R tifier Corporation for military applicati Data on ruggedized silicon substitutes many standard vacuum tubes may be obtai from our Military Products Department.

International

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RECTIFIERS FOR ALL DC REQUIREMENTS...FROM MICROWATTS TO MEGAWATTS!

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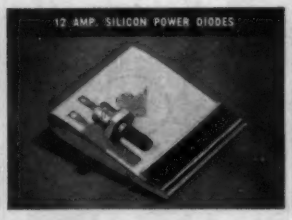
All designed and manufactured to meet the most rigid military requirements!

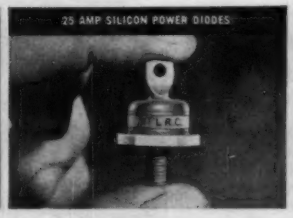
POWER TYPES FOR INDUSTRIAL AND MILITARY APPLICATIONS

SILICON AND SELENIUM — MEDIUM CURRENT TYPES TO 150 AMPS

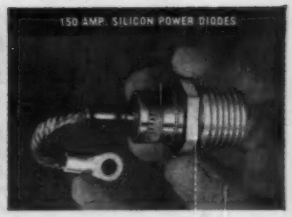
Utilizing junctions rated to 1.25 amps DC output
These stacks consist of hermetically sealed junction diodes mounted on copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 1.25 amps. DC output: 70 to 350 AC input volts rms. Request **Bulletin SR-137A**



Conservatively rated to provide a substantial safety factor in industrial applications. Hermetically sealed, all-welded case construction provides reliability over a long life. Types available in a wide voltage range. For details **Contact Factory.**

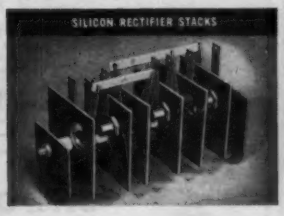


Rating: 50 to 500 volts PIV • 25 to 45 Amps.
Advanced ceramic techniques assuring excellent thermal characteristics and mechanical stability are used in the production of these highly reliable, hermetically sealed rectifiers for military or industrial applications. For complete technical data, request **Bulletin SR-304**

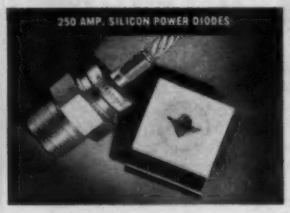


Ratings: 50 to 600 volts PIV • 45 to 150 Amps.
An extensive series of standard and reverse polarity types. Optional mounting bases including machine thread and pipe thread types. Machine thread base types: **Bulletin SR-300.** Pipe thread base types. **Bulletin SR-301.** Complete stack assemblies: **Bulletin SR-302**

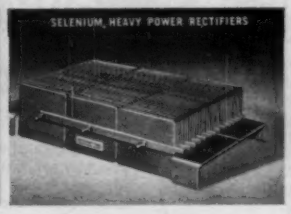
SILICON, SELENIUM AND GERMANIUM — HIGH CURRENT TYPES



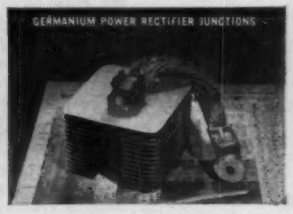
Ratings: 45 to 150 Amperes per Junction
Consisting of hermetically sealed junction diodes mounted on aluminum or copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 45 to 150 amps average DC. Write for application data.



Ratings: 50 to 800 volts PIV • 75 to 250 Amps.
Standard and reverse polarity types offered in a series of machine thread and pipe thread mounting styles. Complete assemblies in all circuit configurations also available. Rugged construction and hermetic sealing assure long life and reliability. Ask for **Bulletin SR-305**



Ratings: 6 to 30,000 volts • 50 to 2,300 Amps.
Specifically designed for industrial DC power needs. Patented construction features assure long life. Descriptive bulletins available are: **Bulletin C-349,** (26 volt cells); **Bulletin SR-160,** (45 to 52 volts per cell) and **Bulletin SR-152,** on high current density cells.



Ratings: 500 amperes • 26 to 66 volts rms
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Complete series of AC and DC types.
Designed to eliminate arcing and erosion across the contacts of relays, switches, etc. A complete series in each of three basic types: diode type, cartridge type and hermetically sealed types for industrial application. For complete data: **Bulletin SR-130-A**

Ratings: From 400 milliwatts to 10 watts
A complete series in 6 types. Miniature single junction types, multiple junction types and double anode units. 750 milliwatt and 1 watt types: **Bulletin SR-251,** 3.5 and 10 watt types: **Bulletin SR-252,** Multiple junction 5 watt types: SR-253, Double anode types: SR-254

Temperature compensated for stability to ±.001%°C
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Self-generating cells available in standard and custom sizes, mounted or unmounted. For details on wide selection of selenium types, request **Bulletin PC-649.** Silicon solar cells in mounted and unmounted types are described in technical detail—specify **Bulletin SR-156.**

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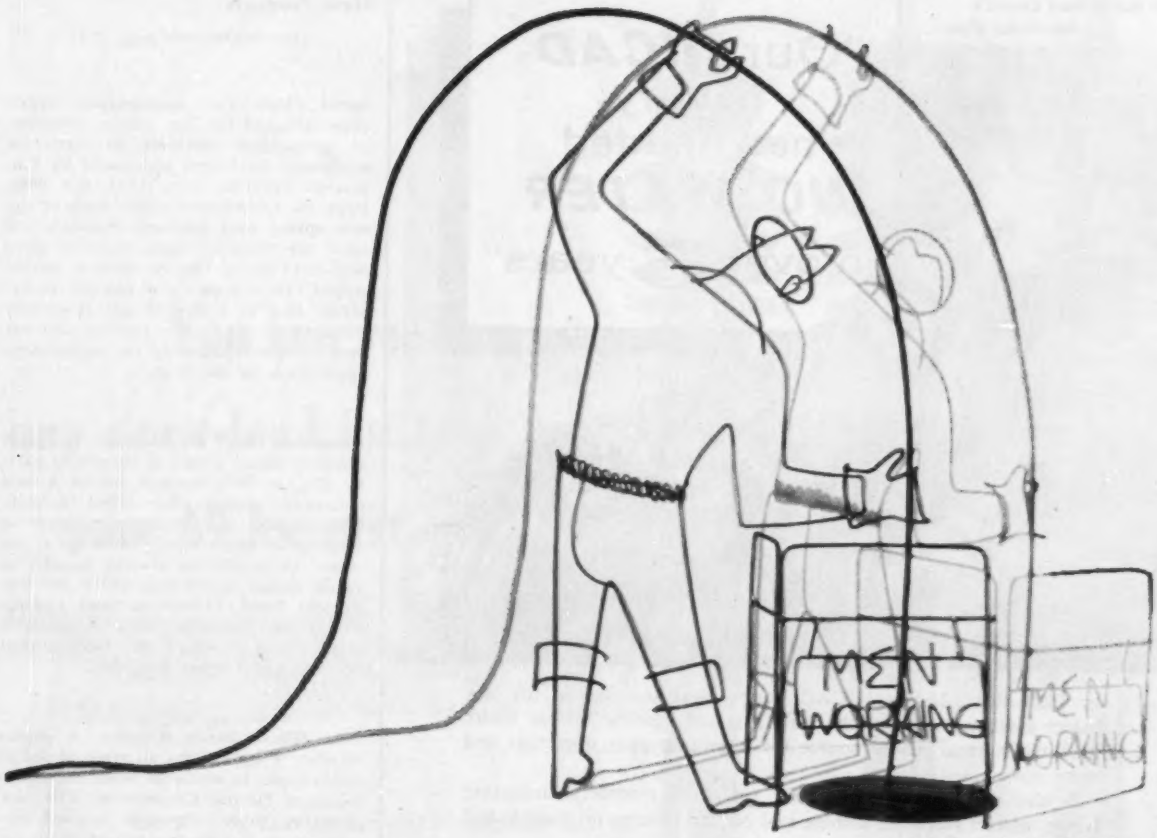
A series of four articles, compilations of papers originally presented at a symposium on electrical properties of semiconductors and the transistor, held during the AIEE Summer General Meeting, Swampscott, Mass., June 1949. Sponsored by the Subcommittee on Electrical Properties of Solids and Liquids of the AIEE Committee on Basic Sciences.

It is hoped that this pamphlet (S-36, January 1950) will prove useful not only to the practicing engineer and teacher, but also to engineering students as an introduction to this field of electrical engineering.

Price is $0.50 ($0.25 to AIEE members). Send orders to: Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York 18, N.Y.



Wire sculpture by Henry Szafarz

The Inside Story

Beneath the surface, there's a lot going on.

An underground river of power surges through innumerable cables, supplying the electrical energy that keeps the entire community rolling smoothly.

Throughout the nation, Simplex products are used extensively in such applications. This is particularly true of ANHYDREX XX, the ideal all-purpose cable for high-voltage use. This expertly engineered cable is popularly employed in the 2001 to 35,000 volt range, and has a Conductor Temperature Rating of 90°C up to 5 KV (a rating never attained before the development of ANHYDREX XX).

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At New England Electric's Salem Harbor Plant...

In 1951 this 125-volt NICAD battery was installed in the new Salem Harbor station of the New England Electric System where it is the normal power source for circuit breaker operation and valve motors.

It also provides standby power for clock recorders, indicating lamps, motors for main turbine seal oil and bearing oil pumps, and for station lighting in emergencies.

After this battery had been in operation for six years, a regular annual inspection found it to be in excellent, "like-new" condition ... and no water additions had been necessary since installation!

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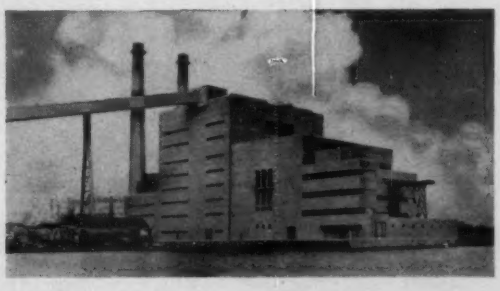
Combine these advantages with those of long life, rugged construction, and long-term economy through uninterrupted service, and you see why use of NICAD batteries assures the most reliable performance at the lowest annual cost.

Ask us for more information on NICAD storage batteries.

New England Electric's Salem Harbor Plant



NICAD DIVISION

GOULD-NATIONAL BATTERIES, INC.

Easthampton, Massachusetts

New Products

(Continued from page 28A)

Speed Clips. Two multipurpose speed clips, designed for fast, simple mounting of germanium rectifiers to electronic equipment have been announced by Tinnerman Products, Inc., P. O. Box 6688, Dept. 16, Cleveland 1, Ohio. Both of the new spring steel fasteners eliminate the need for threaded studs, separate nuts, and lockwashers. One of them is merely zipped over a square stud molded on the plastic base of a rectifier and is entirely self-retained. The other rectifier clip has been designed primarily for replacement application in the field.

Aluminum Alloy for Castings. Designers can now reduce weight of aluminum parts by 25% to 40% through use of a new aluminum casting alloy called Tens-50. Castings can be called out instead of forgings in many cases. The alloy is designed to permit the average foundry to attain design minimums, which are Permanent Mold, 45,000 psi; Sand Casting, 42,000 psi. Technical data is available from Navan Products Inc., International Airport, Los Angeles 45, Calif.

New Silicon Power Rectifier. A silicon rectifier, Type *329*, for all types of power applications is available from the Westinghouse Electric Corporation. The new unit can provide average forward currents up to 160 amperes-per-cell in single-phase circuits or 150 amperes-per-cell in 3-phase circuits with maximum peak inverse ratings up to 500 volts. Features of the new proper rectifier include: high ambient temperature operation—up to 190 C junction temperature long life, high efficiency, low regulation, rugged construction, and small size. For further information, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Self-Propelled Crane. Moving heavy component parts in and out and around plant buildings always presents a problem in materials handling. There are several ways of solving it, including overhead cranes, fork-lift trucks, and self-propelled cranes, depending on plant layout and design, operating economy, and convenience. The Coles self-propelled crane, with a cantilever-type boom, is equipped with a Hercules *DD-226* diesel engine specified to meet the need for an engine which could pick-up load quickly and yet perform satisfactorily with long periods of idling. The engine drives a generator which, in turn, provides power for separate motors controlling the various crane actions. The engine is one of the Hercules line of interchangeable models which, with but few modifications, can be used with diesel or gasoline fuel. Hercules Motors Corporation, 101 Eleventh St., S.E., Canton, Ohio.

(Continued on page 36A)

You can replace *any* draw-lead bushing on your 69 kv system

with one of these LAPP POC* BUSHINGS!

Here's a real saving for you in simplification of warehouse inventories and reduction of costs! No matter how many types of transformers may be on your system . . . no matter how old they may be . . . any bushing replacement requirement can be met by the Lapp POC* ASA Standard bushing.

At 69 kv, for example, the Lapp POC* draw-lead (400 amp) bushing is made in just three shank lengths. Present transformer designs call for these bushings. On any older transformer using a pre-standard bushing, one of these will also fit perfectly; all that is required is a simple flange adapter which provides for differences in mounting details, and for length and clearances.

Lapp can supply POC* Bushings for your stand-by stocks in voltage ratings 15 kv to 161 kv. Also, we'll design and supply, at nominal cost, non-magnetic flange adapters which will adapt these ASA Standard bushings to every transformer on your system. Give us data on the transformer bushings you now have in service. Let us show you the economies you can effect by reducing your entire stock of spare bushings to the required sizes of Lapp POC* Bushings and a suitable assortment of flange adapters. You'll never be without the replacement bushing you need, and you will save spectacularly in warehouse space . . . in stock maintenance labor costs . . . in investment in inventory. Lapp Insulator Co., Inc., Le Roy, New York.

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POC* BUSHING

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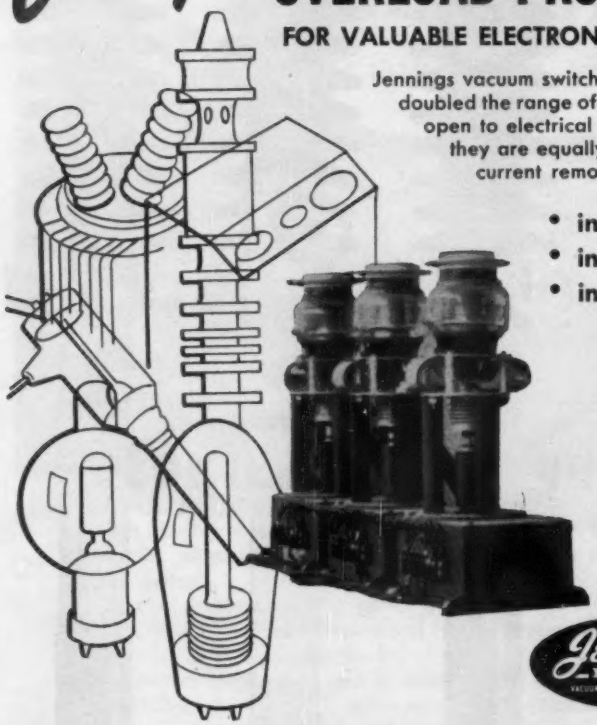
TOTALLY-ENCLOSED CORE
ASA STANDARD

Complete OVERLOAD PROTECTION

FOR VALUABLE ELECTRONIC EQUIPMENT



Jennings vacuum switches have more than doubled the range of design possibilities open to electrical engineers because they are equally effective for fault current removal

- in primaries
- in secondaries
- in dc lines

Jennings RADIO
VACUUM ELECTRONIC COMPONENTS

Extremely fast, reliable operation characterizes Jennings Vacuum Overload Circuit Breakers regardless of where they are used in the circuit. Positive interruption at first current zero in either high or low voltage ac circuits limits arc time to less than 8 milliseconds. Total operation, including relaying and arc time, is accomplished in one half to one cycle for the fastest fault current removal obtainable anywhere. Comparable dc interruption at higher power levels is made possible by placing a capacitor and damping resistor in series across the switch contacts.

Complete Overload Circuit Breaker units are composed of a high voltage instantaneous trip overcurrent relay, a N/O vacuum relay, and a control box, any of which may be purchased separately. Auxiliary 2PDT contacts are available so that three phase circuits may be wired for simultaneous operation.

Rapid recovery of very high dielectric strength achieves the short time, low energy arcing which results in remarkably long contact life. Metal loss from ½ inch contacts per 1,000 operations is only 0.0002 inch for a 100 amp resistive load. Vacuum sealed contacts need no maintenance and eliminate the danger of fire and explosion.

For more details on the finest in high speed overcurrent protection write Jennings today.

JENNINGS RADIO MANUFACTURING CORP., 970 McLAUGHLIN AVE., P.O. BOX 1272-E, SAN JOSE 8, CALIF.

New Products

Continued from page 34A

Miniatures with Plastic Doors. The Ratographic line of miniature indicating, recording, and controlling instruments is now available with optional plastic or metal doors. Plastic doors provide superior visibility and are gasketed to keep out dust, dirt, and harmful vapors. All features of the miniature instruments are retained: plug-in construction permits interchangeability of chassis without interruption of process; chassis can be withdrawn to the "inspection position" exposing 14 hours of chart record and providing easy accessibility to all adjustments without disturbing operation; controllers can be plugged into rear manifold; 4-inch wide linear strip chart provides maximum readability. For more information, write Fischer & Porter Company, 756 Jacksonville Rd., Hatboro, Pa.

Photoprints for Layout Use in ¼ Scale. The Bristol Company is making ¼-scale photoprints of its instrument line available to engineers, designers, and other persons concerned with instrumentation layout. A survey of layout pratices showed 1:4 to be the scale most commonly used. The new cut-out and paste-on technique makes a clear, accurate picture of proposed control panel easily available durin gearly planning stages. The ¼-scale photo reproductions of both full-size and miniature electronic and pneumatic control and recording instruments are offered. Write to Bristol Company, Waterbury 20, Conn.

Precise Coaxial Glass Cell. A precision coaxial glass cell, which assures accurate external referencing of high resolution nuclear magnetic resonance spectra, is being marketed by Wilmad Glass Company, Inc., Landisville, N. J. The cell is comprised of coaxial precision glass tubes. The center tube retains the sample while the region between the tubes contains the reference standard. This practice permits the sample and the standard to be subjected to a common external magnetic field without polluting the pure system as in internal referencing. The glass in the Wilmad cell is so free of imperfections that errors caused by line broadening and field shifts are negligible.

Microvolt-Ammeter. A d-c microvolt-ammeter which measures d-c voltages from 1 microvolt to 1 volt and d-c currents from 1 micro-microampere to 3 milliamperes is now available from the Hewlett-Packard Company, 275 Page Mill Rd., Palo Alto, Calif. The instrument, Model *425A*, has an accuracy of ±3% full scale. Use of a photoconductive chopper in place of the conventional mechanical vibrator helps achieve high sensitivity and reduces drift to less than 2 microvolts per hour after warm-up. Noise is less than 0.2 microvolt rms. Model *425A* has a full-scale voltage sensitivity of ±10 microvolts and a full-scale current sensitivity of ±10 micro-microamperes. Thus, it is useful in nearly all branches of scientific measurement, including medical, biological, and chemical research.

Federal Pacific Metal-Clad Switchgear is made compact...rugged... and in increasing numbers!

Federal Pacific Metal-Clad Switchgear does the job—it's proven by the growing list of installations across the United States and abroad. Most important, Federal Pacific does it with stronger materials, fewer parts, most modern design, and complete safety to operating personnel.

It's rugged...it's safe...it's easy to maintain...it's accepted!

For the full Federal Pacific Metal-Clad Switchgear story call your Federal Pacific engineer or write for Catalog No. 3-440, Federal Pacific Electric Company, Newark, New Jersey.

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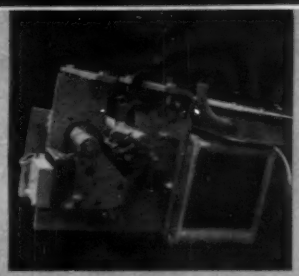

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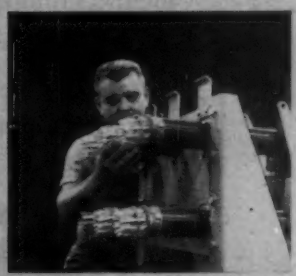
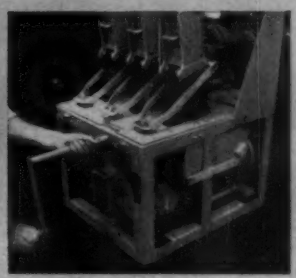


• **PRIMARY DISCONNECTS ASSEMBLY MOUNTS ON BREAKER AS A UNIT**—Complete six stud bushing sub-assembly mounted directly on breaker facilitates inspection and service.



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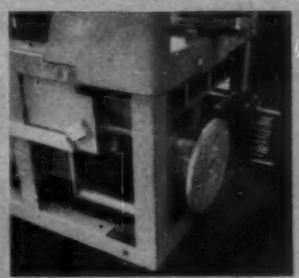

• **CLOSING SOLENOID MAINTAINS TORQUE TO END OF STROKE**—Plunger disc gives solenoid additional pull at the end of the stroke when most needed...to compress closing springs and make positive contact.

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As much as we like the idea of standardization, the one thing we have learned is that there is no cut-and-dried, assembly-line, easy way to produce substations.

We've been at it 28 years, producing more than 900 substations of all kinds, and it has always been tough for us!

Even stations with essentially the same assignments have endless arrangements. Infinite combinations of design preclude standardization. Each station must be virtually a custom-made project.

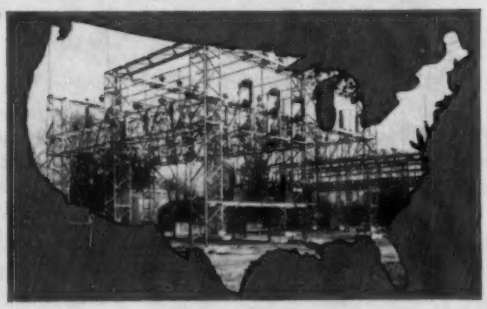
True, hundreds of designs in our files are helpful. Many standard components are picked up and used, with ultimate savings to our customers. And the practical experience of our design staff guides us around many pitfalls.

But you can't escape the fact that supplying substations requires these basic functions: skillful engineering, careful detailing, precise coordination of production schedules, and delivery on time. At least, that's what we've learned. And that's how Southern States approaches every substation assignment.

On this basis, you might like to do business with us. We'll welcome your inquiry. Just call your Southern States representative or write direct to us.

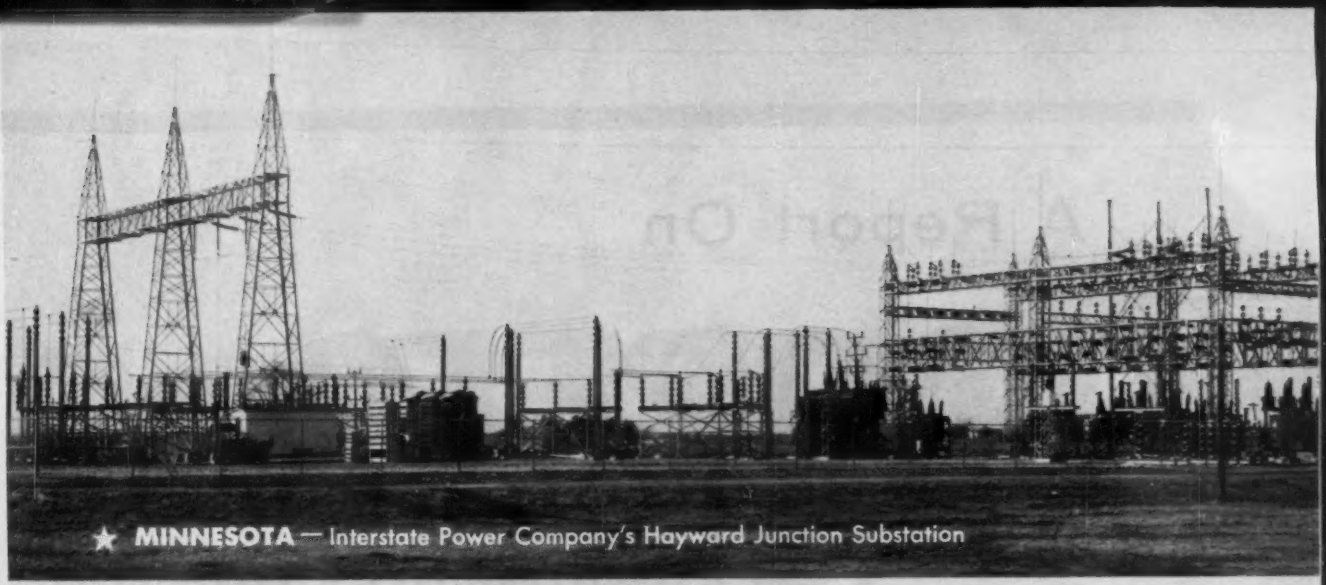
SOUTHERN STATES SUBSTATIONS ARE IN USE ALL OVER THE NATION

During the past 28 years Southern States has produced 910 outdoor substations for hundreds of different customers. The stations range from small 5,000 kva units to switchyards exceeding 1,000,000 kva. Regardless of size, Southern States pays close attention to every detail—from the single-line wiring diagram to the finished station.



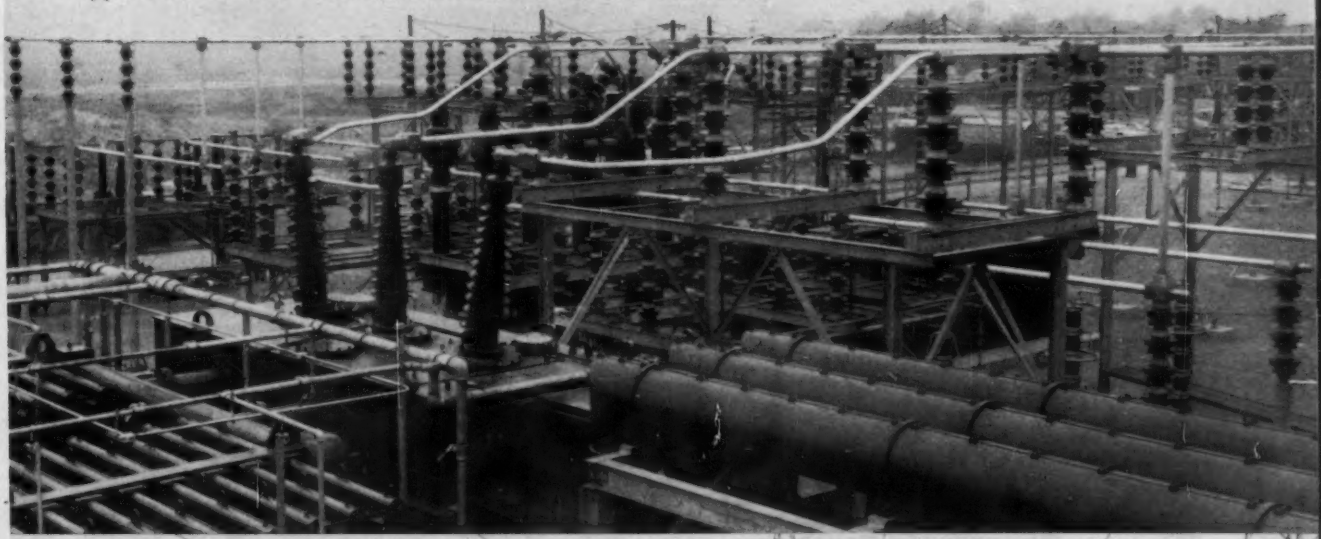
SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

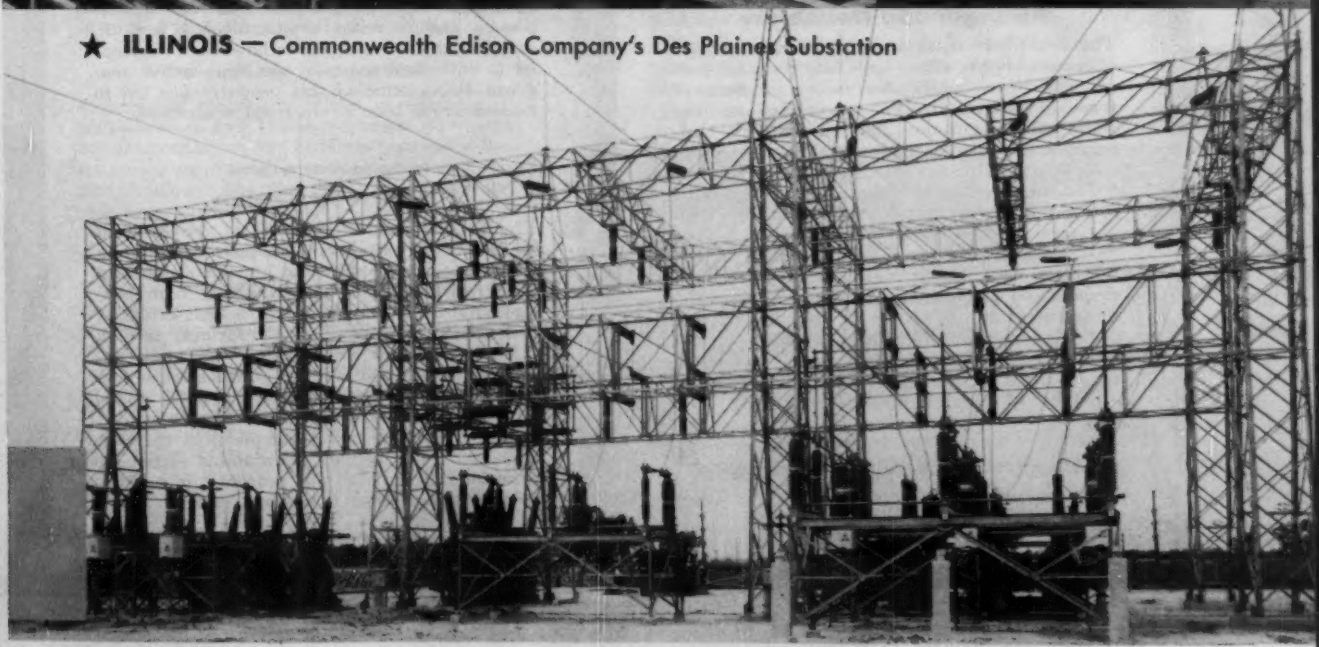


★ **MINNESOTA** — Interstate Power Company's Hayward Junction Substation

★ **NEW YORK** — Consolidated Edison's Corona Substation



★ **ILLINOIS** — Commonwealth Edison Company's Des Plaines Substation



In each of these substations Southern States worked closely with the utility, designing and detailing the structures; and supplying many components, including structural steel, air break switches, disconnects, buses, cable conductors, connectors, and bus supports.

A Report On

COPPER and

8 points to consider

Today, with copper readily available, a new direction in electrical and electronic design is becoming apparent. There is a growing acceptance that many of the important new design requirements *besides* conductivity can be met by copper itself — as alloys, as laminates and as the pure metal. Sometimes it is merely the method of use which is changed to achieve optimum performance. But this is not just a rediscovery of copper — it is also the creative development of new alloys and new usages.

Here are just eight of the more important design requirements, besides conductivity, which are currently being met by some form of copper:

Conductivity plus
Strength and Reliability

The flexibility, resiliency and fatigue strength of certain copper alloys have long dictated their use wherever reliability was important. Some of these alloys have excellent mechanical qualities while still maintaining high conductivity. Cadmium bronze, for example, is 99% copper with tensile strengths, for hard-drawn wire, up to 90,000 psi. Excellent spring qualities with fatigue strength and wear resistance, even at high temperatures, can be obtained with beryllium copper. Superfine-grain phosphor bronze is a relatively new development useful in applications where enduring contact-point pressure is most important.

The reliability of the copper operative parts of electromechanical choppers is a basic reason for the return to these in place of electronic types in a number of missile applications.

Conductivity plus Heat
Dissipation and Hot Strength

Heat conductivity, of course, usually parallels electrical conductivity. In addition to the obvious uses of this property in heat exchange apparatus and appliances, many current applications are taking advantage of copper's heat conductivity, plus its good joining properties, to conduct heat away from more delicate components by means of cooling vanes and heat sinks.

Chromium copper's greater strength at elevated temperatures is finding new uses in mechanical-electrical parts such as commutator segments and resistance-welding electrodes. At 200C, for example, its tensile strength is about twice that of tough-pitch copper.

Conductivity plus
Corrosion Resistance

Commercially pure copper affords excellent resistance to industrial, marine and rural atmospheres, and to water, steam, alcohol, fuel oil, gasoline and sewage. Alloys have been developed to withstand many of the more active reagents. Recognition of this property has led to non-electrical uses in electrical equipment.

Conductivity plus
Forming Facility

The hot and cold workability of copper itself is excellent. In addition, coppers containing small amounts of tellurium have good machining properties while still retaining high conductivity. And extruded shapes can often be used to minimize the amount of forming needed.

Interesting new examples of copper's workability include cold rolling to thicknesses less than .0005 inches (for missile computer applications, foil coil transformers and flexible printed circuits). Another new development is the cold hobbing of solid copper, maintaining extremely close tolerances. With this process it is possible to produce *one-piece* magnetron cavities.

its ALLOYS

besides conductivity

Conductivity plus Joining Facility

Copper is, of course, easily and firmly soldered. Many of its alloys also lend themselves well to brazing and to oxyacetylene or gas-shielded arc welding. New methods of inert-gas metal-arc welding make it easy to weld pure copper.

Conductivity plus Bonding Facility

Copper's affinity for plating has made possible, for the first time, a really good bond with titanium, by flash coating the base metal with copper before plating with titanium. New developments in printed commutator-type circuits can take advantage of the exceptional wear resistance of rhodium because of the good bond it will form with the copper conductive layer. Continuing research is also being done on laminates of copper with other metals and plastics.

Conductivity plus Finish

Copper and most of its alloys, particularly the nickel silvers and low-zinc brasses, are useful for ornamentation and housings because of their cold-working properties and their ease of plating and finishing. The new fine-grain brasses provide a surface ideal for high finish.

Conductivity plus Availability

The copper industry's mine reserves and productive capacity are at a new high. Copper and copper alloys are now available in more shapes, sizes and material specifications than ever before. The long-range prospects are so good as to completely dispel any reservations lingering from the post-war years when stock-piling gave a surface appearance of short supply. Domestic mine capacity is scheduled to increase at an average rate of well over 20,000 tons per year. Free-world capacity, allowing for depletions, shows a projected 15% increase during the next five years.

And a word about conductivity itself. Even this classic property of copper merits a new examination. For example — silver-bearing copper, containing only 8 to 30 ounces of silver per ton, retains the high conductivity of copper, but has higher softening temperatures—and at commercially practical prices. Speaking of price, have you compared copper lately on a cost-per-mho basis with any other conductive metal you might be considering? You will find that this cost of conductance now makes it particularly economical to take advantage of copper's other properties.

The Copper & Brass Research Association is anxious to cooperate with you in finding a better way to solve your problems with copper. Write CABRA, 420 Lexington Avenue, New York 17, New York.

There's a new frontier in...

COPPER
BRASS
BRONZE

FREED

MIL-T-27A POWER, FILAMENT, PULSE & AUDIO TRANSFORMERS

FOR IMMEDIATE DELIVERY FROM STOCK

POWER TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Hi Volt Sec.	ct	DC Volts	DC Amps	Filament #1 Volt	Filament #1 Amp.	Filament #2 Volt	Filament #2 Amp.	MIL Case Size
MGP1	400/200	√	185	.070	6.3/5	2	6.3	3	NA
MGP2	650	√	260	.070	6.3/5	2	6.3	4	JB
MGP3	650	√	245	.150	6.3	5	5.0	3	KB
MGP4	800	√	318	.175	5.0	3	6.3	8	LB
MGP5	900	√	345	.250	5.0	3	6.3	8	MB
MGP6	700	√	255	.250					KB
MGP7	1100	√	419	.250					LB
MGP8	1600	√	640	.250					NB

FILAMENT TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Secondary Volt	Secondary Amp	Test VRMS	MIL Case
MGF1	2.5	3.0	2,500	EB
MGF2	2.5	10.0	2,500	GB
MGF3	5.0	3.0	2,500	FB
MGF4	5.0	10.0	2,500	HB
MGF5	6.3	2.0	2,500	FB
MGF6	6.3	5.0	2,500	GB
MGF7	6.3	10.0	2,500	JB
MGF8	6.3	20.0	2,500	KB
MGF9	2.5	10.0	10,000	JB
MGF10	5.0	10.0	10,000	KB

PULSE TRANSFORMERS

Cat. No.	Block'g. Osc.	Int. Coupl'g	Low. Pow. Out.	Pulse Voltage Kilovo.ts	Pulse Duration Microseconds	Duty Rate	No. of Wdgs.	Test Volt. KVRMS	Char. Imp. Ohms
MPT1	√	√		0.25/0.25/0.25	0.2-1.0	.004	3	0.7	250
MPT2	√	√		0.25/0.25	0.2-1.0	.004	2	0.7	250
MPT3	√	√		0.5/0.5/0.5	0.2-1.5	.002	3	1.0	250
MPT4	√	√		0.5/0.5	0.2-1.5	.002	2	1.0	250
MPT5	√	√		0.5/0.5/0.5	0.5-2.0	.002	3	1.0	500
MPT6	√	√		0.5/0.5	0.5-2.0	.002	2	1.0	500
MPT7	√	√	√	0.7/0.7/0.7	0.5-1.5	.002	3	1.5	200
MPT8	√	√	√	0.7/0.7	0.5-1.5	.002	2	1.5	200
MPT9	√	√	√	1.0/1.0/1.0	0.7-3.5	.002	3	2.0	200
MPT10	√	√	√	1.0/1.0	0.7-3.5	.002	2	2.0	200
MPT11	√	√	√	1.0/1.0/1.0	1.0-5.0	.002	3	2.0	500
MPT12	√	√	√	0.15/0.15/0.3/0.3	0.2-1.0	.004	4	0.7	700

AUDIO TRANSFORMERS
Freqn. resp. 300 to 10000 cps ± 2 DB. All Case Sizes AI

Catalog No.	Application	Impedance Prim. Ohms	Impedance Ct.	Impedance Sec. Ohms	DC Current Ct.	DC Current Prim. P. Side Mid Max. Unbal. Ma.	DC Current Max. Level DBM
MGA1	Single or P.P. Plates — to Single or P.P. Grids	10K	√	90K Split	√	10 10	+15
MGA2	Line to Voice Coil	600 Split		4, 8, 16		0 0	+33
MGA3	Line to Single or P.P. Grids	600 Split		135K	√	0 0	+15
MGA4	Line to Line	600 Split		600 Split		0 0	+15
MGA5	Single Plate to Line	7.6K 4.8T		600 Split		40 40	+33
MGA6	Single Plate to Voice Coil	7.0K 4.8T		4, 8, 16		40 40	+33
MGA7	Single or P.P. Plates to Line	15K	√	600 Split		10 10	+33
MGA8	P.P. Plates to Line	24K	√	600 Split		10 1	+30
MGA9	P.P. Plates to Line	60K	√	600 Split		10 1	+27

Write for futher information on these units and special designs and complete line of Mil-T-27 Reactors also available from stock. Send for complete catalog.

FREED TRANSFORMER CO., INC.
1700 Weirfield Street
Brooklyn (Ridgewood) 27, New York

INDUSTRIAL NOTES

Plant Dedicated in Massachusetts. A new facility for the production of liquid oxygen, nitrogen, and argon was put on stream at South Acton, near Boston, Mass., by the Air Reduction Sales Company, a Division of Air Reduction Company, Inc. The new air separation facilities will produce 75 tons of the liquefied gases daily. Home offices for Air Reduction Company, Inc., are at 150 E. 42nd St., New York 17, N. Y.

Pulse Engineering Representative. Northport Engineering Company has been appointed to represent Pulse Engineering, Inc., 2657 Spring St., Redwood City, Calif., manufacturer of miniature pulse transformers. Northport Engineering will cover Minnesota, North and South Dakota, and Western Wisconsin from their St. Paul office.

Oil Reclaimer Completed. A large mobile Hilco oil reclaimer was recently completed by The Hilliard Corporation, 100 W. Fourth St., Elmira, N. Y. The Model *500-X* Duplex, Hilco Hyflow oil reclaimer is designed for purification of transformer insulating oils in the field to prevent oil or transformer breakdown. The reclaimer removes water, sludge, acids, and other oil oxidation products, dissolved paint, bushing compound, metallic soap, and other contaminants.

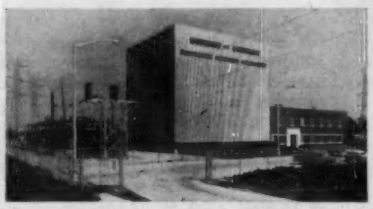
Navigational System Production Plant. A recently dedicated International Business Machines (IBM) military products plant in Owego, N. Y., is producing the bombing navigational system for the *B-52* Intercontinental Bomber of the Strategic Air Command (SAC). The plant will also develop a stellar-inertial bombing and navigational missile guidance system for the chemically fueled, high-altitude *B-70* SAC bomber. This newest IBM plant is of steel frame construction with brick facing and aluminum trim which assures ruggedness and permanence. Blue-green porcelain panels provide a striking architectural contrast.

STRAD. An electronic communication system which sharply reduces the time required to handle telegraph messages for control of aircraft has been installed at Gatwick Airport, near London, England. The new system, known as STRAD (switching, transmitting, receiving and distribution system), is made by Standard Telephones and Cables, Limited, London, an affiliate of International Telephone & Telegraph Corporation, 67 Broad St., New York 4, N. Y. Messages from domestic and overseas sources are received by STRAD, recorded, sorted, and directed to the recipients or, if required, to many recipients simultaneously. Switching and sorting is done at high speed by electronic devices built into the system.

Dymec, Inc. Effective now, Dynac, Inc., Palo Alto, Calif., has changed its name to Dymec, Inc., according to an announcement by R. E. Rawlins, president. The change was made necessary by a conflict with a previously registered trademark of another company. The action is a name change only; there is no change in the ownership, management, or policies of the company.

Dynel Fabric for Radar Shell. Reinforced plastic spherical radome structures used in the radar network of the North American defense line are protected from harsh elements of Arctic weather by an overlay fabric of Dynel, Union Carbide's acrylic fiber. The huge spheres are manufactured by Long Sault Woodcraft Limited for the Royal Canadian Air Force's Pine Tree Defense Line, and the United States Air Force. Designed to replace radomes of the rubber .air-inflated type, the hard shell globe comes in 156 panels that have tongue-and-groove edges for quick, easy assembly and portability. The entire unit can be shipped in one plane load and can be erected on virtually any site in approximately 125 man-hours. For further information contact Textile Fibers Department, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y.

Electrical Testing Laboratory in Illinois. Hubbard and Company recently opened an electrical testing laboratory at McCook, Ill., with an all-day series of demonstrations of the laboratory's facilities, which can dupicate the conditions encountered in present-day and future utility systems.



A unique feature of the new building is a 60-foot high-voltage surge generator. Among the equipment is a 3.2-mv impulse generator, an 80-kw per second 100-kv surge current generator, and a 600-kv 60-cycle high-voltage test set. For a complete description of the testing facilities, write to Hubbard and Company, 5401 W. Roosevelt Rd., Chicago 50, Ill.

Company Move. Navan Products, Inc., subsidiary of North American Aviation, Inc., is moving its general offices from Santa Monica, Calif., to 900 N. Sepulveda Blvd., Imperial, International Airport, Los Angeles 45, Calif. Specializing in the marketing of inventions, Navan is now selling several products through its own organization, including a new, precise diamond cutoff wheel, a high-strength aluminum alloy, a revolutionary box closure that replaces nails and permits reuse of box panels, a new static seal for hydraulic fittings, and an all-metal preservative.

(Continued on page 46A)

THERE IS NO SUBSTITUTE FOR SPAULDING FIBRE ON INDUSTRY'S "BENCH"

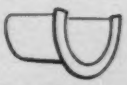
When industry adds up the qualities of Spaulding Vulcanized Fibre, there is but one conclusion. For countless uses there is no substitute.

No other material combines its forming, punching, insulating and arc resisting qualities. None can compare with its machinability, low heat conductivity, compressibility, abrasive resistance and deionizing properties.

For light weight combined with mechanical strength, Spaulding Vulcanized Fibre stands supreme.

Its applications are endless. Its cost is low. Next time, look to Spaulding Fibre. Learn why it's indispensable to industry.

For over 25 years no satisfactory substitute has been found for **SPAULDING FIBRE** for these applications



For Cable Bushings
because of its excellent forming and insulating properties plus abrasion resistance.

For Lightning Arrestors
because of its arc snuffing properties and shock resistance.

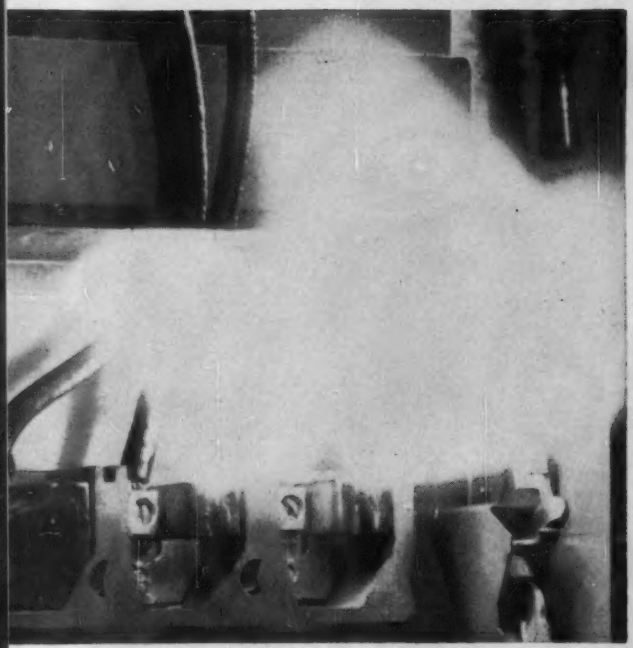
For Railroad Track End Posts
because of its compression strength and electrical insulation.

For Textile Bobbins
because of its lightweight and smooth wearing qualities.

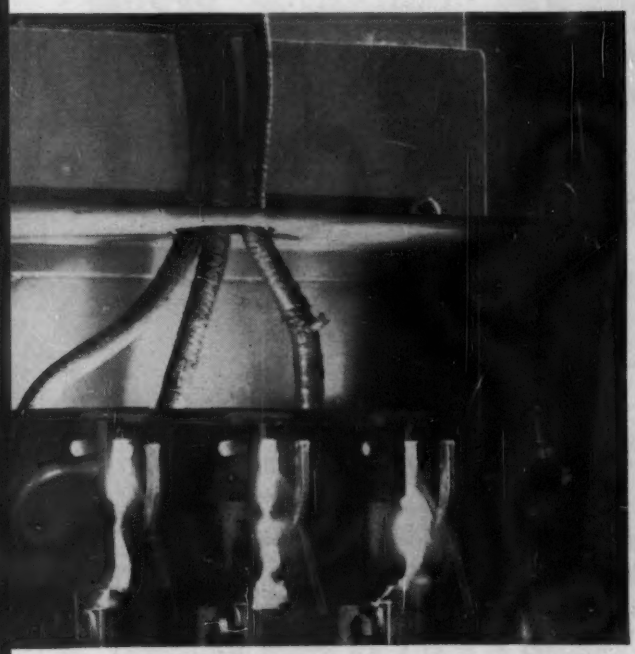
SPAULDING FIBRE COMPANY, INC.
307 WHEELER STREET
TONAWANDA, N. Y.

***WRITE** US FOR ADDRESS OF OUR NEAREST SALES OFFICE*

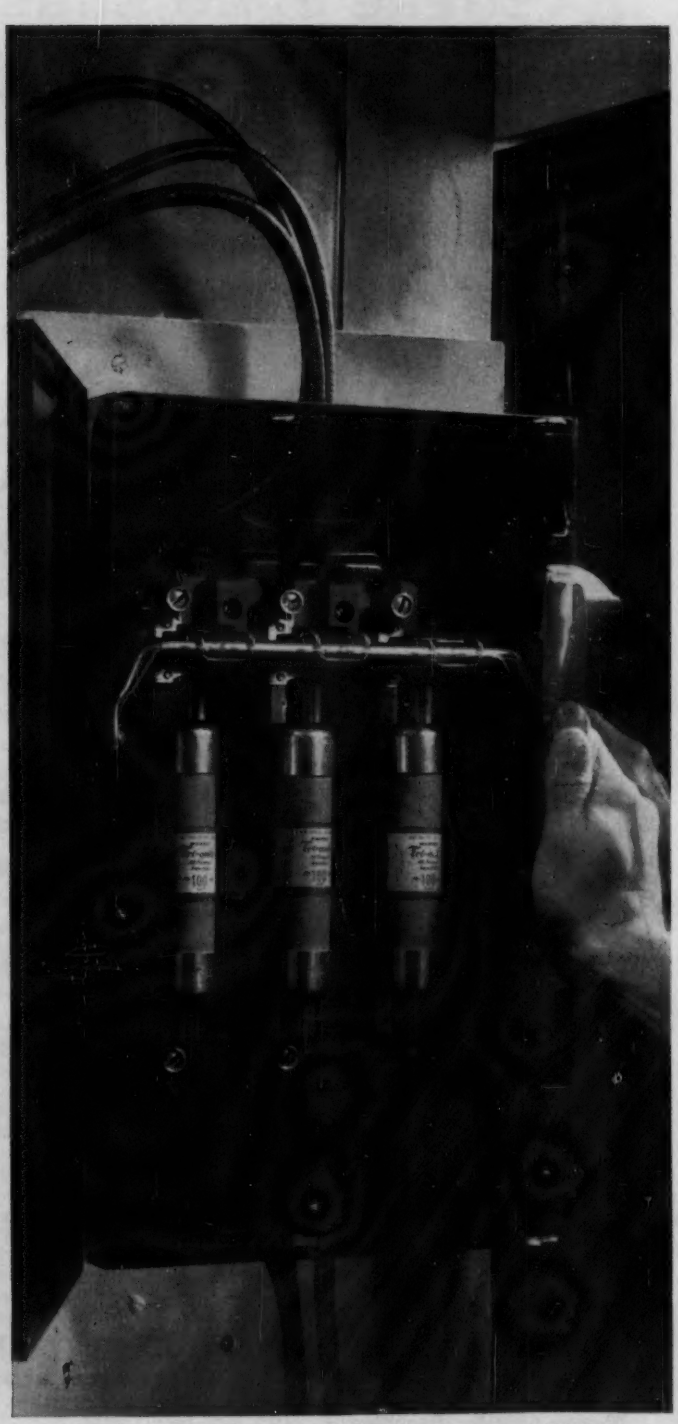
FOR SAFETY'S SAKE:



1. RUINOUS ARC in open knifeblade switch. At moment of "break" a flash explosion occurs. Blades pit, burn, deteriorate. Danger of fire is ever-present in open blade switches.



2. SUBDUED ARC in modified knifeblade switch. Closures or "quenchers" retard arcing slightly, but since blades must ultimately be pulled clear of closures the hazards still exist.



3. MAXIMUM SAFETY found only in BullDog Vacu-Break* Safety Switches. Arcing is confined inside compact Vacu-Break chambers. Arcs are snuffed out before they can cause any serious damage.

Unretouched photographs of the arc in 100-amp 600-volt switches operating under 90-amp 440-volt load with 40% to 50% power factor. All pictures taken at exact instant of "break".

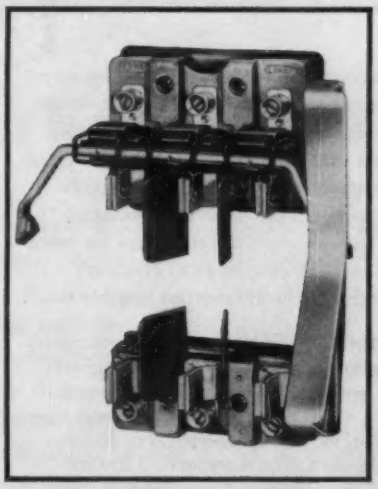
Let's take a good, long look at safety in today's safety switches

THERE'S A BIG DIFFERENCE in safety switches—a difference between maximum safety and half-way safety . . . low maintenance and excessive maintenance. These differences are quickly apparent when you compare BullDog Vacu-Break® Safety Switches with the other main type—the open knifeblade switch.

BULLDOG discarded the knifeblade design twenty years ago when they engineered the Vacu-Break. It is based on the engineering principle that an arc is the least destructive or dangerous if confined in an arc chamber which limits the oxygen supply . . . actually starves the arc before it can build up. "Explosions" are non-existent . . . the need for maintenance of contact points is virtually eliminated. Today, only BullDog has the Vacu-Break or anything like it. And it is available at no extra cost on both the Master and Junior types.

OPERATION of the Vacu-Break is simple, sure and safe. A sturdy rod attached to the operating handle is clamped directly to the Vacu-Break heads. When the handle is pushed "Off", this rod literally yanks the heads away from the stationary contacts. *Double "break" action is quick, foolproof.* Unlike knifeblade types, you need not depend on tricky spring and trigger mechanisms. You don't have to open the switch cover and check to see that contact has been broken!

100,000 AMP TEST. BullDog Vacu-Break Safety Switches, when used with current-limiting type Amp-traps**, will withstand the most severe fault currents. In recent tests standard BullDog switches with Amp-traps have been subjected to a 100,000 amp short circuit current. *The switches were undamaged!*

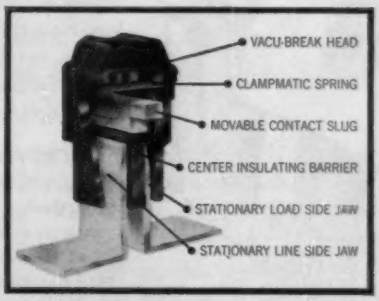


Vacu-Break heads are connected directly to the switch handle. No toggles or triggers, no tricky springs . . . no danger of switching failure. One of several exclusive BullDog Vacu-Break features that set the performance standards for the industry.

THE CLAMPMATIC ASSEMBLY (see the illustration below) is another safety feature of BullDog Vacu-Break Safety Switches. It gives bolt-tight contact in the "On" position, helps accelerate "break" when the switch is pushed "Off".

VALUE. You pay no more for Vacu-Break Safety Switches . . . yet you get the maximum in safety and full-time performance. *Compare*—and you'll buy BullDog. See your electrical distributor, contractor, or call a BullDog field engineer.

© BEPCO



Close-up of Vacu-Break head shows movable contact slug inside the compact, oxygen-limiting chamber. Clampmatic assembly assures bolt-tight contact, speeds "break". This combination guarantees positive, safe operation, long switch life.

BULLDOG

BullDog Electric Products Company, Division of I-T-E Circuit Breaker Company, Detroit 32, Mich. *BullDog Export Division:* 13 East 40th St., New York 16, N.Y. *In Canada:* BullDog Electric Products Co. (Canada) Ltd., 80 Clayson Rd., Toronto 15, Ont.

* *Vacu-Break and Clampmatic are registered trademarks of the BullDog Electric Products Company.*

** *Amp-Trap is a registered trademark of the Chase-Shawmut Company.*

"Our engineers get more done, thanks to the Bendix G-15 computer"

says J. H. MITCHELL, *vice-president*
LOCKWOOD, KESSLER & BARTLETT • SYOSSET, NEW YORK

"As a civil engineering firm with a part in many major construction projects we have a heavy load of design computations. Before we acquired a Bendix G-15, our engineers had to do this tedious work themselves, as part of each highway or structural design problem. Now the computer does these mathematical chores, and the engineers can use their time for more creative work. The G-15 enables us to give our clients optimum designs in the shortest possible time."

THE G-15 PROVIDES • Low-cost versatility for thousands of office and laboratory applications • Simplified operating methods • Memory and speed of computers costing four times as much • Typewriter input-output, paper tape output and 250 char/sec paper tape input at no added cost • Expandability through accessories for 1,200,000 words of magnetic tape storage and punched card input-output • Extensive program library • Users share programs Proven reliability • Nationwide service • Lease or purchase.

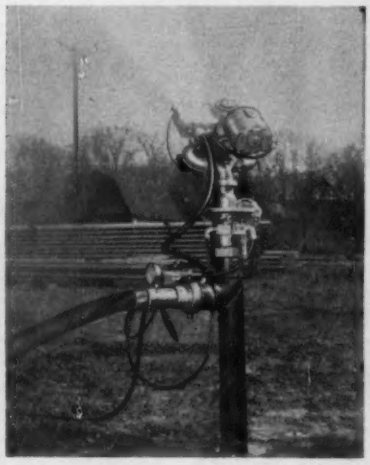
Bendix® Computer DIVISION OF BENDIX AVIATION CORPORATION

Built and backed by Bendix, the G-15 is serving scores of progressive businesses large and small throughout the world. For details, write to Bendix Computer, Department K5, Los Angeles 45, California.

Industrial Notes

(Continued from page 42A)

Automatic Unit Cuts Rocket Launching Fire Loss. In the past, when fires broke out at the Cape Canaveral launching site, scientists had to watch helplessly as valuable equipment went up in flames. The heat was so intense that no fire fighting equipment could be manned to prevent complete destruction of rockets and instruments. Under urgent contract, Akron Brass Manufacturing Company, Inc., 1450 Spruce, Wooster, Ohio, has perfected and

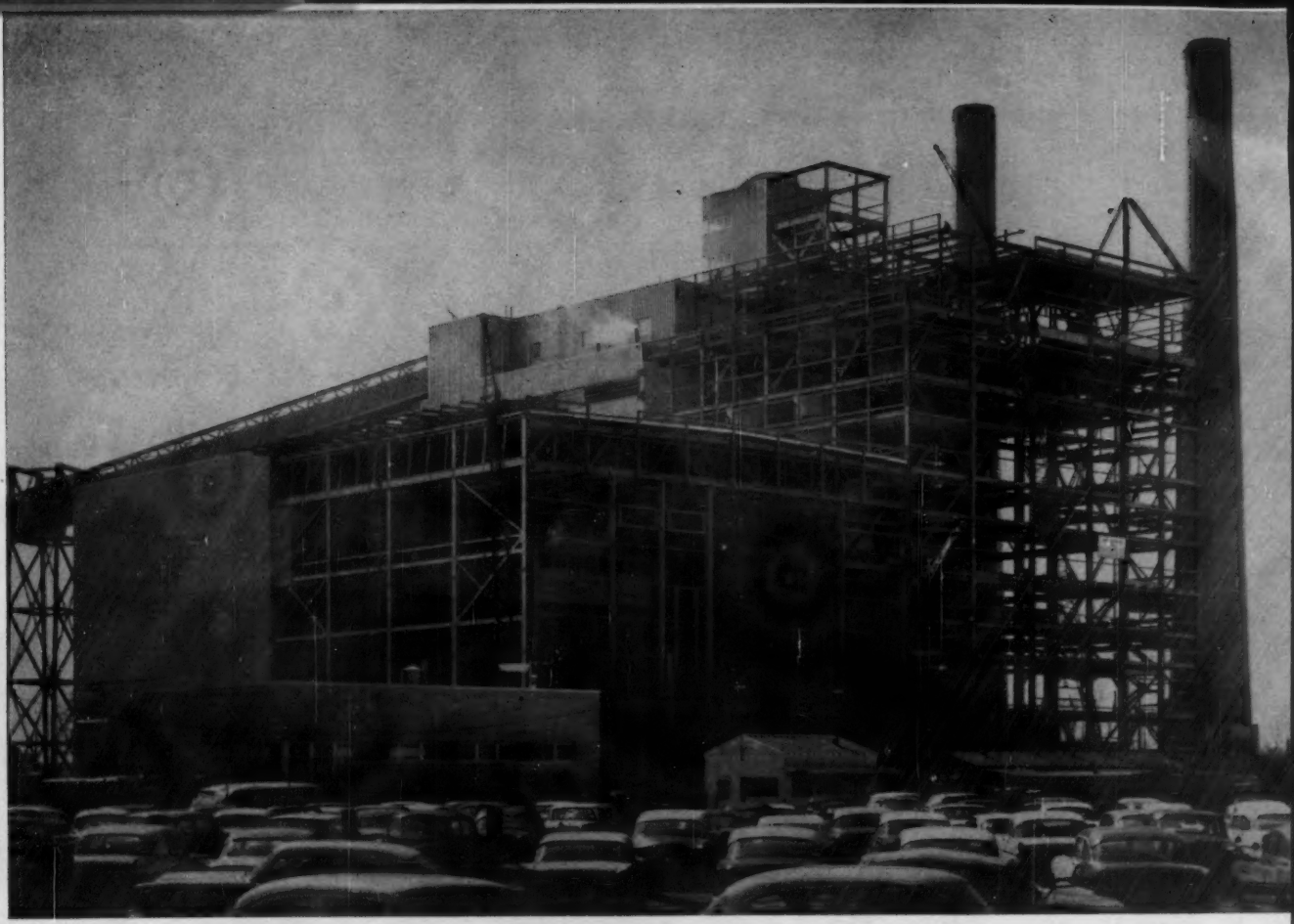


delivered several completely automatic units which are mounted at the base of the launching stand. Remote controls, placed in the observation bunker a quarter of a mile away, raise, lower, rotate, and change stream widths of the units, all directed with the aid of field glasses. Unox foam is used with the units, tests having shown it a successful additive in the quenching of intensely hot rocket fuel fires.

High-Purity Tantalum. Achievement of commercial production of very high purity tantalum metal, a development of major significance to both military and civilian areas of the electronics, chemical processing, atomic energy, and other industries, has been announced by National Research Corporation, 70 Memorial Drive, Cambridge 42, Mass.

Automatic Programming System. Devcon, Inc., 11 Washington Ave., Plainfield, N. J., manufacturers and designers of control systems, announces the development of a new programmer and recorder system designed as a control unit in the pilot plant production of gasoline by catalytic reforming. The machine, installed in the process laboratories of Esso Research and Engineering Company, Linden, N. J., precisely times and monitors many of the intricate events that take place in controlling the regeneration of the catalyst used in the process. The device is capable of programming 48 complete cycles of operations, each consisting of 15 separate events in sequential relationship.

(Continued on page 50A)



Powerhouse that grew

The Toledo Edison Company sets the pace for the growth of the area it serves... *by building for the future.*

Typical of the dynamic power industry, the Toledo Edison Company anticipated future expansion when they designed Bay Shore Station No. 1. Now, less than three years after completion of this modern unit, it is being doubled in size to keep ahead of the growing demand for dependable electric power.

American Bridge, which built the first Bay Shore Unit for Toledo Edison Company, also fabricated and erected the steel for Bay Shore Station No. 2.

Transmission towers, too! American Bridge has been designing and fabricating transmission towers for Toledo Edison Company for 38 years! A few years ago, incidentally, we designed and delivered *ninety-two* 100′ high towers to this growing Midwestern power company for its 15-mile Bay Shore 138,000-volt line.

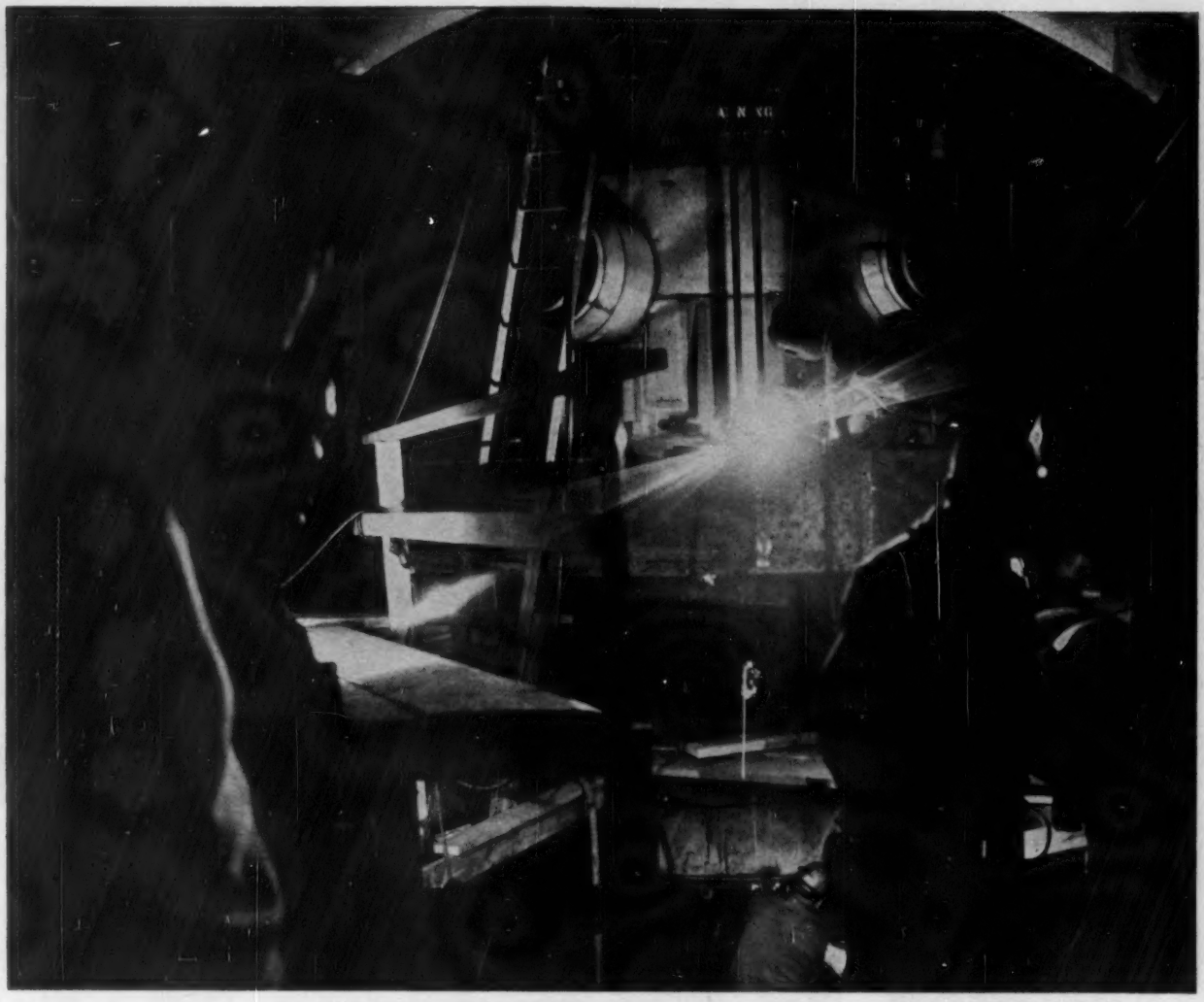
USS is a registered trademark

American Bridge Division of USS United States Steel

General Offices: 525 William Penn Place, Pittsburgh, Pa.

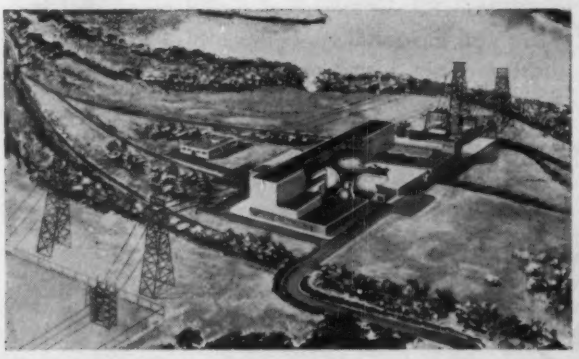
Contracting Offices in: Ambridge • Atlanta • Baltimore • Birmingham • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Elmira • Gary • Houston • Los Angeles Memphis • Minneapolis • New York • Orange, Texas • Philadelphia • Pittsburgh • Portland, Oregon • Roanoke • St. Louis • San Francisco • Trenton

United States Steel Export Company, New York

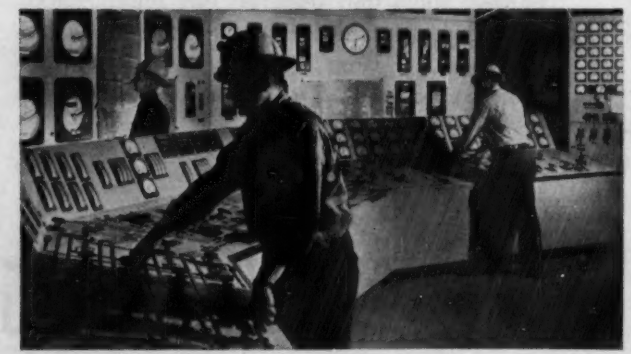


Photos by Robert Yarnall Richie

Rome's station control cable installed



Artist's Sketch of first U. S. full-scale atomic-electric plant. This revolutionary power plant—under the operation of Duquesne Light Company of Pittsburgh—delivers electricity to home and industry in the Pittsburgh area.



Atomic-Electric Power is controlled from this large cabinet installation at the Shippingport atomic power station. Nearly ten miles of Rome's highest quality station control cable are used in this vital system.

Partner to the Atom. Rome's control cable is here being installed in the nation's first major atomic power plant at Shippingport, Pennsylvania. Rome Cable furnished over 50,000 feet of station control cable for this important installation.

in Shippingport atomic power station

This country's first full-scale atomic power plant for the generation of electricity contains almost ten miles of Rome's highest quality station control cable.

The selection of Rome's Rozone-Roprene cable—with a special over-all asbestos outer braid—for this epoch-making installation was no accident, for individual Rozone insulated-Roprene jacketed conductors represent the ultimate in control cable design and performance.

Advantages of Rozone insulation. Rozone—a high-quality oil-base compound—is an excellent insulation. Long and widespread experience has proved that its high-dielectric and impulse strength, combined with its resistance to corona and ozone cutting, makes it an ideal insulation for control and high-voltage power cables. Its electrical properties are practically unaffected by long-time immersion in water or burial in the ground.

Advantages of Roprene jacket. Roprene—a neoprene synthetic rubber compound developed by Rome Cable—provides an extremely durable and permanent mechanical protective covering for the individually Rozone-insulated conductors. It assures terminations that are resistant to abrasion, weather, and attack by chemicals and oils. And it is exceptionally resistant to fire.

Additional fire protection for this particular cable included a special over-all asbestos outer braid.

Specify premium-quality Rozone-Roprene control cable for your next job. Contact your nearest Rome Cable representative for more information—or write to Department 802R, Rome Cable Corporation, Rome, New York.

ROME CABLE

CORPORATION

BIDDLE
CORONA
TESTING EQUIPMENT
... for non-destructive evaluation of electrical insulation in transformers, cables, capacitors and other electrical components.

Control cabinet and test transformer available as separate units on casters for mobility, for testing specimens with terminal capacitance up to 0.15 MUF and impedance to ground of 20,000 OHMS or more. (Power output maximum of 20 KVA at 20 KV 60 CPS.) On special order this equipment can be supplied for maximum output power at 20 KVA at maximum test voltage 30 KV 60 CPS.

Safety, simplicity, and reliability have been engineered into all Biddle Corona Testing Equipment. Care has been taken to make the indication of corona as simple and self-evident as possible.

For sensitive test equipment these sets are extremely rugged, and surprisingly easy to operate, even by personnel not specifically trained for making electrical measurements. All this without sacrificing sensitivity of corona detection and reproducibility of test results.

With the Biddle Corona Test Set non-destructive evaluation of insulation by corona testing is now practical as a production control of quality of insulating structures.

Whatever your requirements in this field of testing explore the complete line of Biddle Corona Testing Equipment—for complete details write for **Bulletin 66—EE.**

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Industrial Notes

(Continued from page 46A)

New Massachusetts Plant. Hermon Hosmer Scott, president of H. H. Scott, Inc., manufacturers of high fidelity components, announces completion of a 32,000 square foot plant in Maynard, Mass. The new plant, located on Route 62 between Maynard and West Concord, is built on one level to allow continuous manufacturing. It is of simple, modern design and is constructed of brick, with spectrum colored panels along the side walls. The plant has complete facilities for the manufacture and fabrication of electronic equipment. It includes a complete machine shop, sheet metal shop, coil and transformer department, testing department, and electrical assembly department, as well as office and storage space. It has a completely staffed engineering development laboratory.

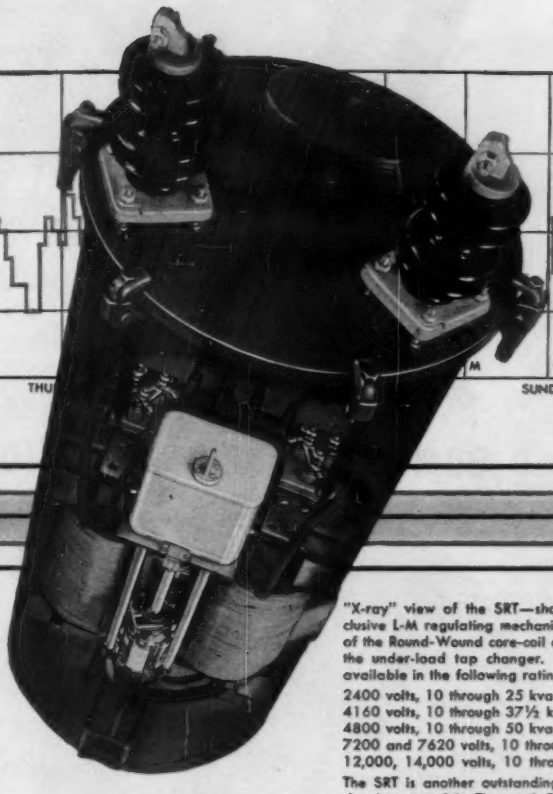
Explorer I Mercury Batteries. The tiny mercury batteries used in the Explorer I satellite to send back to earth a constant tracking signal from outer space have exceeded significantly their life expectancy. The battery pack used to provide energy for a low power beacon from America's first successful satellite had a nominal expectancy of 60 days and a maximum of approximately 110 days. The battery pack, weighing slightly more than two pounds, actually lasted 112 days. Mercury batteries, manufactured by The Mallory Battery Company of Cleveland, a Division of P. R. Mallory & Co. Inc., Indianapolis, Ind., were also used for Explorer I's telemetering circuits. These batteries powered the small telemetering oscillators. The output of these circuits modulated the beacons. They expired after 73 days in outer space.

Phalo Moves to "Model Plant." High on a hill overlooking a wooded valley in Shrewsbury, Mass., the new plant of Phalo Plastics Corp., 530 Boston Turnpike, is a model layout for production of wire and cable. The one-story construction, about four miles from Phalo's original location in downtown Worcester, Mass., is of brick with vast areas of glass, surmounted at one end by capacious tower facilities for lacquer-coating.

White Alice Communications Contract. Federal Electric Corporation, Paramus, N. J., has announced that it has been awarded a $17,679,122 contract by the U. S. Air Force to maintain and operate the White Alice communications system in Alaska for the 1958-59 fiscal year. The White Alice system, utilizing such forms of modern communications as microwave, over-the-horizon tropospheric scatter radio systems, and telephone lines, serves military, Civil Aeronautics Administration, and civilian needs in Alaska. Federal Electric Corporation also maintains and operates the famed Distant Early Warning (DEW) Line, a 3,000-mile radar chain that stretches all the way from northwestern Alaska to the east coast of Baffin Island. The White Alice system provides communications to a number of DEW Line stations located in Alaska.

Actual utility company load curve on a transformer for an August week.

With SRT, voltage would have been kept within the band width (blue lines)



"X-ray" view of the SRT—showing the exclusive L-M regulating mechanism at the top of the Round-Wound core-coil assembly, and the under-load tap changer. SRT's will be available in the following ratings:

2400 volts, 10 through 25 kva
4160 volts, 10 through 37½ kva
4800 volts, 10 through 50 kva
7200 and 7620 volts, 10 through 75 kva
12,000, 14,000 volts, 10 through 100 kva

The SRT is another outstanding engineering development of the Thomas A. Edison Laboratories of McGraw-Edison Company.

HERE is L-M's New SRT the World's First Self-Regulating distribution Transformer

Provides regulation at the point of use; corrects overvoltage and undervoltage in four 2½% steps; improves utility company revenue and provides better service for utility customers.

By **ROBERT P. THOMPSON**
Manager of Engineering, Transformers
Line Material Industries

The new L-M Self-Regulating distribution Transformer should make an outstanding contribution to profitable, economical utility operation. By providing regulation *at the point of use*, the SRT improves revenue by avoiding loss in billings caused by *undervoltage;* and it gives customers better service by more efficient operation of lights, appliances, and all other electrical devices. By preventing *overvoltage*, it reduces burnouts of lamps and television tubes.

L-M Round-Wound Design

The SRT is basically a Round-Wound® transformer with extra taps on the *primary*, and an under-load tap changer. The voltage regulating mechanism is volt-sensitive on the *secondary*, so voltage is maintained within a 3½-volt band width centered around 120 volts.

"Adapt-A-Tap" Range Selector

The "Adapt-A-Tap" range selector provides a full 20% range within which the taps for the 10% automatic regulation may be selected—all below, straddle, or all above normal. Thus the SRT may be located anywhere on the line—at the end, in the middle, or near the substation. Four 2½% steps are provided. Operation occurs only after a time delay to prevent undesirable operation and "hunting" on switching surges and momentary voltage changes outside the band width.

More Economical Regulation

The SRT provides extremely economical regulation, *at the point of use*, and it opens wider horizons to the distribution system design engineer for more effective system planning.

Sold For Test Program

The limited initial production of SRT's will be sold to utility companies who wish to make thorough tests of the possibilities of this revolutionary new engineering development. These tests should enable utilities to determine the extent to which SRT's may be applied, and the best methods of application.

Ask The L-M Field Engineer

For details about the SRT, ask the L-M Field Engineer who calls on your company; or write A. R. Waehner, Director of Transformer Sales, Line Material Industries, Milwaukee 1.

LINE MATERIAL Industries
McGRAW-EDISON COMPANY

Distribution Transformers

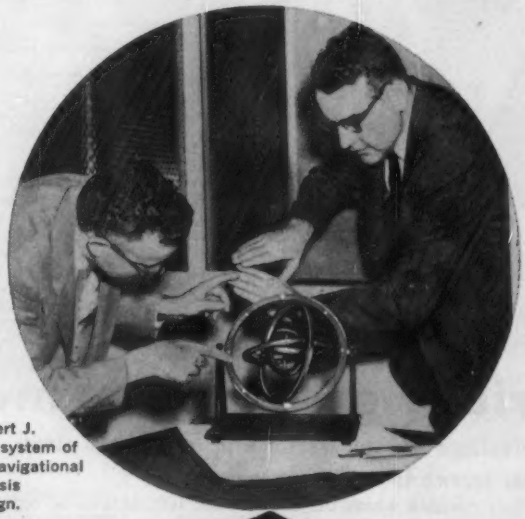
McGRAW EDISON

852

Circuit Development Group Leader Ralph Wolcott (left) considers future changes in computer output unit for bombing—navigational systems.

Ground-floor opportunities in

INTEGRATED BOMBING-RADAR-NAVIGATIONAL SYSTEMS *at* IBM



Project Engineer Robert J. Cantwell (left) uses a system of gimbals to describe navigational problems in the analysis of a new system design.

The design and development of advanced airborne computers at IBM Owego offer an unusual professional opportunity to engineers and scientists today. At this IBM Military Products facility you now have a chance to work on completely integrated bombing-radar-navigational systems. And it's just like joining a new company — the ground-floor opportunities you will find at IBM Owego. In addition, you have all the advantages . . . all the security . . . of IBM.

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Staff Engineer William Howard (center) reviews gearing accuracy requirements of test equipment with electronic circuit designers.

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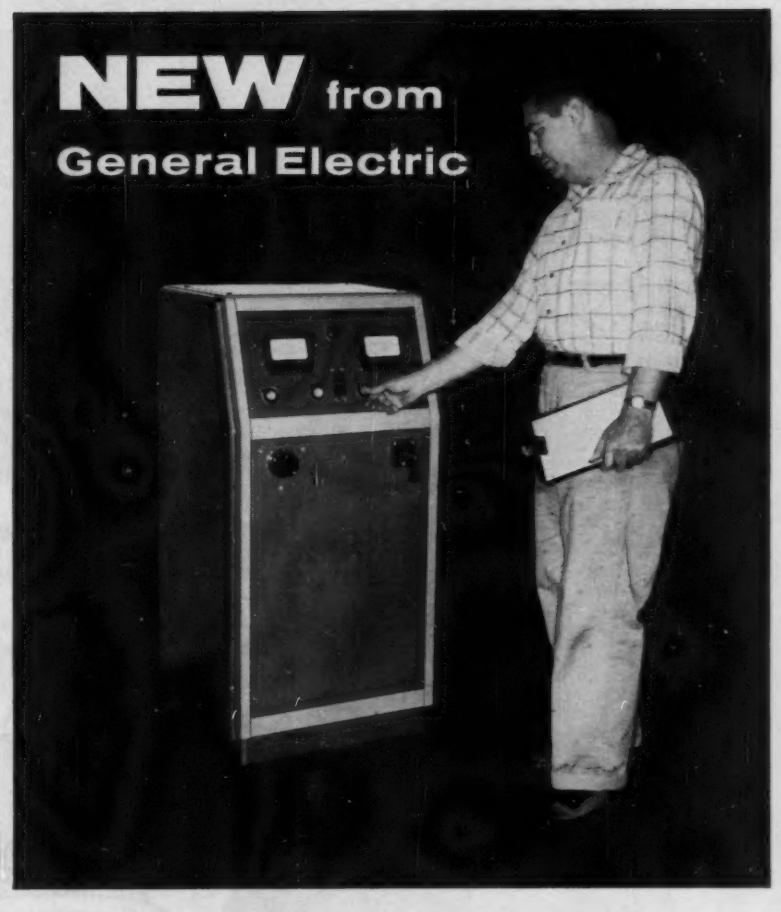

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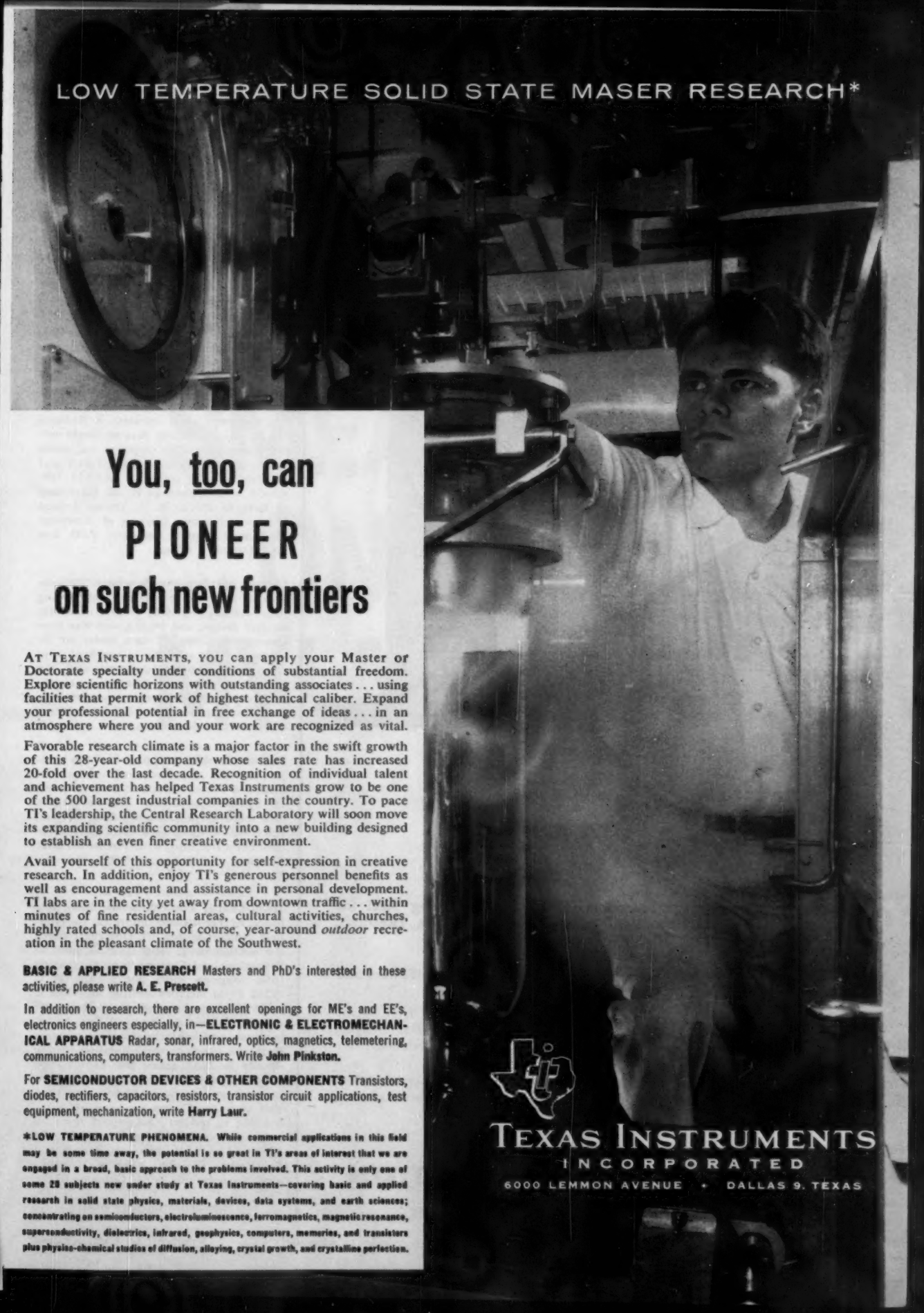

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For **SEMICONDUCTOR DEVICES & OTHER COMPONENTS** Transistors, diodes, rectifiers, capacitors, resistors, transistor circuit applications, test equipment, mechanization, write **Harry Laur.**

***LOW TEMPERATURE PHENOMENA.** While commercial applications in this field may be some time away, the potential is so great in TI's areas of interest that we are engaged in a broad, basic approach to the problems involved. This activity is only one of some 28 subjects now under study at Texas Instruments—covering basic and applied research in solid state physics, materials, devices, data systems, and earth sciences; concentrating on semiconductors, electroluminescence, ferromagnetics, magnetic resonance, superconductivity, dielectrics, infrared, geophysics, computers, memories, and transistors plus physico-chemical studies of diffusion, alloying, crystal growth, and crystalline perfection.

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TRADE LITERATURE

Bulk Tape, Film Eraser Folder. A new bulk eraser which automatically erases magnetic signals from new and recorded tape or film is fully described in a 4-page folder recently issued. Included in the folder is information on the features, construction, and operation of the eraser, which is designed to handle 35 mm or smaller film, and tapes up to 1½ inches in width. For copies of this brochure, write Radio Corporation of America, Building 15-1, Camden, N. J. Request Form *3R 3338*.

Aircraft Facility and Induction Motor Bulletins. Completely integrated research, design, development, and production facilities for aircraft and missile subsystems and components are described in Bulletin *2100* recently released by The Leland Electric Company, Also released, is Bulletin *104* in which selection data on single and polyphase integral horsepower induction motors up to 20 hp are covered. Letterhead requests for free copies of Bulletin *2100* should be addressed to H. M. Haas, and of Bulletin *104* to R. A. Young, Leland Electric Company, Division of American Machine & Foundry Company, P. O. Box 1060, Dayton 1, Ohio.

Contact Specifications Brochure. Publication of a brochure covering engineering data, contact selection, contact materials, contact design, and contact sizes has been announced. Complete data tables are included for the selection of standard solid rivet types, button contacts, and the typical properties of Conmet materials. For a copy, write on company letterhead to Contacts Incorporated, 1100 Silas Deane Hwy., Wethersfield, Conn.

Facilities Booklet. A 24-page facilities booklet describes the diversified products of Fischer & Porter Company, manufacturers of flowmeters, process instrumentation, data reduction and automation equipment, chlorination equipment, and glass products. For a free copy, write Fischer & Porter Company, 792 Jacksonville Rd., Hatboro, Pa.

Metal Charts. Two charts have been published by Fansteel Metallurgical Corporation, North Chicago, Ill. One chart shows the melting points of the metals, both in Fahrenheit and Centigrade scales, ranging from tungsten which melts at 3,400 C (6,152 F) to mercury melting at —38.8 C (—38 F), and the other chart shows the densities of metals, grouped into heavy, medium, and light classifications, ranging from the heaviest metal, osmium, whose density is 22.48 grams per cubic centimeter (g/cc), to the lightest metal, lithium, whose density is 0.53 g/cc, less than that of water. Charts are available without cost to readers who request them on company letterheads. Requests should be addressed to E. R. Jenstrom, Metals and Fabrication Division, Fansteel Metallurgical Corporation, North Chicago, Ill.

(Continued on page 60A)

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		Max. Cable Dia." Table 11 N.E.C.	Number of Conductors in one Cable ROCK PNR	3/64" 4/64"	Max. Cable Dia." Table 11 N.E.C.	Number of Conductors in one Cable ROCK PNR	3/64" 4/64"	Max. Cable Dia." Table 11 N.E.C.	Number of Conductors in one Cable ROCK PNR	3/64" 4/64"	Max. Cable Dia." Table 11 N.E.C.	Number of Conductors in one Cable ROCK PNR	3/64" 4/64"
½"	New Work	.450	2-4		.243			.234			.195		
	Rewiring	.479	2-4		.276			.252			.218		
¾"	New Work	.598	5-7	2-3	.323			.311			.260		
	Rewiring	.636	5-6	2-4 2	.367			.335			.290		
1"	New Work	.762	8-14	4-7 2-4	.412	2-3		.396	2		.331		
	Rewiring	.811	9-16	5-8 3-5	.468	2-4		.427	2-3		.370		
1¼"	New Work	1.000	15-19	8-12 5-8	.543	4-5	2-3	.523	3-5	2-3			
	Rewiring	1.070	17-19	9-16 6-9	.618	5-6	2-4	.564	4-5	2-3			
1½"	New Work	1.170		13-19 9-12	.634	6-8	4 2	.610	6-7	4			
	Rewiring	1.248		10-14	.721	9-11	5-7 2-4	.658	6-9	4-5 2			

This is an excerpt from the Rockbestos Conduit Fill Chart. Write today for your free copy. Ask for PNR 1-58.

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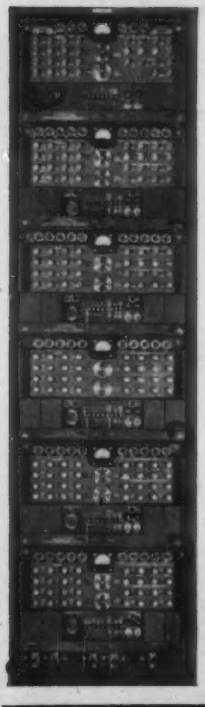

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Two miniaturized voice-multiplex systems providing four or 24 voice channels over radio or 4-wire cable are available. They have many advantages over earlier designs: high performance, small size, light weight, low cost, circuit simplicity, low power requirements, small number of tubes of a single type only, low operating cost, low maintenance and high reliability.

These systems provide a voice-channel flat within 1 db from 300 to 3500 cycles, for each 4 kc of bandwidth occupied. Each channel is equipped with hybrid, signalling, and dialling circuits for all the standard 2-wire and 4-wire loop options.

The basic unit provides an order-wire and 4 carrier-derived channels. These units can be stacked in groups of 2, 3, 4 or 5 by means of a group modem to provide 9, 14, 19 or 24 channels. Full flexibility is provided for dropping and inserting channel groups at repeater and terminal points. Moderate lengths of 4-wire cable or open-wire line may be inserted between the multiplex equipment and the radio terminals.

24-channel carrier-telephone terminal complete with hybrids, ringing and dialling circuits, and test facilities. Dimensions are 58" high, 16" wide and 8" deep. Power input 250 watts. Weight 326 lbs.

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Trade Literature

(Continued from page 56A)

Measuring Instrument Catalog. A 28-page catalog listing many new measuring instruments describes products and components such as measuring microscopes, cathetometers, optical benches, and accessories to be used with each. The catalog is available from The Ealing Corporation, Box 91, Natick, Mass.

Aluminum-Flattened Wire Folder. A 6-page technical reference folder giving specifications, engineering data, and availabilities of aluminum-flattened wire has recently been published. Copies may be obtained free from any Kaiser Aluminum sales office or from Kaiser Aluminum & Chemical Sales, Inc., Department NR-15, 919 N. Michigan Ave., Chicago 11, Ill.

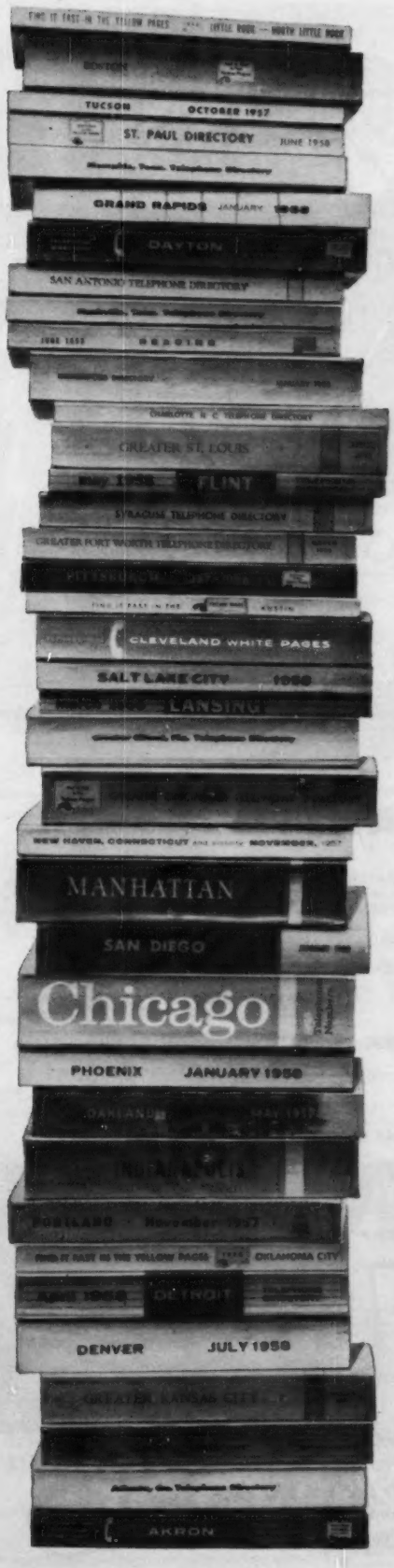
Fire Extinguishing Equipment Brochure. The new "FEMA Handbook of Safety Codes," now available, outlines the various procedures for maintaining, protecting, recharging, and inspecting fire extinguishing equipment commonly used throughout the electrical industry. This new 42-page literature is available at no cost from the Fire Equipment Manufacturers' Association, Inc., One Gateway Center, Pittsburgh 22, Pa.

Radiating Systems and Components Brochure. Publication and availability of a new 32-page brochure, No. *RS 100*, describing the complete facilities and latest products of the Radiating Systems and Components Division is announced by Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif. It contains detailed component data on antennas, antenna arrays, coaxial switches, power dividers, filters, diplexers and multiplexers, impedance matching devices, coaxial cable assemblies, and complete antenna systems. For a copy of this engineering brochure No. *RS 100*, write on company letterhead.

Forced Air Cooling Booklet. A 6-page technical booklet on cooling electronic equipment has been published for electronics engineers, physicists, and builders of rack-mounted electronic cabinets. The purpose of this booklet is to supply engineering information on thermal design and to survey methods of cooling electronic components. Copies of the booklet are available from McLean Engineering Laboratories, P. O. Box 228, Princeton, N. J.

Shrink Tightening Studs Bulletin. Bulletin *L-1244* illustrates how Chromalox electric stud heaters give faster and more accurate shrink-tightening of large studs and holding bolts. They are used in the manufacturing, assembly, and servicing of steam pressure vessels, large presses, motors or turbines—wherever maximum tightness is desirable. Write to Edwin L. Wiegand Company, 7500 Thomas Blvd., Pittsburgh 8, Pa.

(Continued on page 66A)



1 in 35,000,000

How the telephone switching system sorts numbers in seconds

When you dial out of town, the telephone switching system performs an amazing feat. It sorts out the one other number in 35 million you want, and connects you to it in seconds. The other telephone may be thousands of miles away.

Bell Laboratories engineers endowed this great switching network with almost superhuman capabilities. As you dial, the machine listens, remembers, figures out the best route, makes connections, alerts, reports, even corrects itself. If it detects trouble on the way, it files a report, then chooses other circuits and goes on to complete your call. All you are aware of is the end product—the completed call.

Yet at Bell Telephone Laboratories, switching engineers see the present system as only a beginning. Ahead they see—and are developing—new systems vastly more flexible and capable than today's. Nowhere in telephone technology is the challenge greater. Nowhere are dreams coming true faster.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

These Bell Telephone System directories list some of the 35,000,000 telephones now linked by the Direct Distance Dialing system developed at Bell Laboratories. In seconds, this unique machine sorts out and connects you with precisely the number you want.

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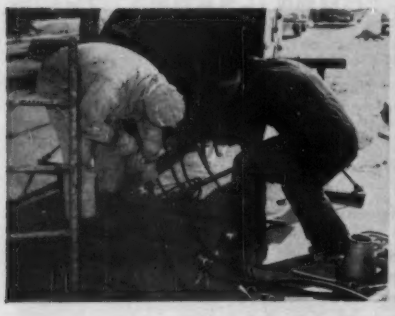
Consolidated Edison is meeting the challenge of mounting demands for electrical power with a systematic program of replacement and expansion. Selected to help carry this ever-increasing load in the Metropolitan New York area is Paranite "Network Power Cable" . . . one of the many Paranite products which backs up a reputation . . . "IF IT'S PARANITE IT'S RIGHT®"

Why PARANITE "NETWORK CABLE?"

Paranite Network Cables are engineered, manufactured, tested and have been proven in installation to meet the severe demands of seasonal peak loads. The consistent performance of Paranite marks it as a product of close quality control!



PARANITE WIRE AND CABLE DIVISION

Essex Wire Corporation, Fort Wayne 6, Indiana

MANUFACTURING PLANTS: Birmingham, Ala.; Anaheim, Calif.; Jonesboro, Ind.; Marion, Ind.; Tiffin, Ohio

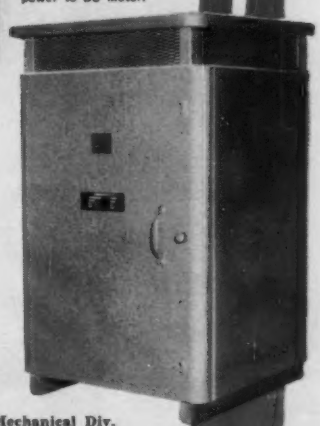
Sales Offices in all Principal Cities

NOW!

Reliable DC Power.. tailored to your needs!

NEW Good-All DC Power Supply Rectifiers

Model shown here is PAWTC 125V—20 amp DC power supply utilizing 220V 3 Phase AC input for supplying power to DC Motor.



Complete range—up to 200 KW DC substations • Adjustable • No moving parts • Low maintenance cost • Selenium, Silicon or Germanium stacks.

For trouble-free, uninterrupted DC power supply specify Good-All. Our custom quality units are engineered to stay on the job, delivering maintenance free RELIABLE POWER week after week, year after year. Order from stock designs or we will build to your specs.

APPLICATIONS:
Battery Charging • Electro Plating • DC Motors • Anodizing • Powering Magnet Coils • Powering Electrostatic Precipitators • Laboratory Power Supplies

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GOOD-ALL ELECTRIC MFG. CO. Electrical-Mechanical Div. OGALLALA, NEBRASKA

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Eastern Joint Computer Conference
(December 1956)

The 30 papers and discussions in this 150-page publication were presented at the Joint Computer Conference, New York, N.Y., December 10-12, 1956. The theme of the conference was new developments in computers.

Publication T-92 was prepared under the sponsorship of the American Institute of Electrical Engineers *Committee on Computing Devices*, The Association of Computing Machinery, and The Institute of Radio Engineers *Professional Group on Electronic Computers*.

Price: $3.00. Send orders to Order Department.

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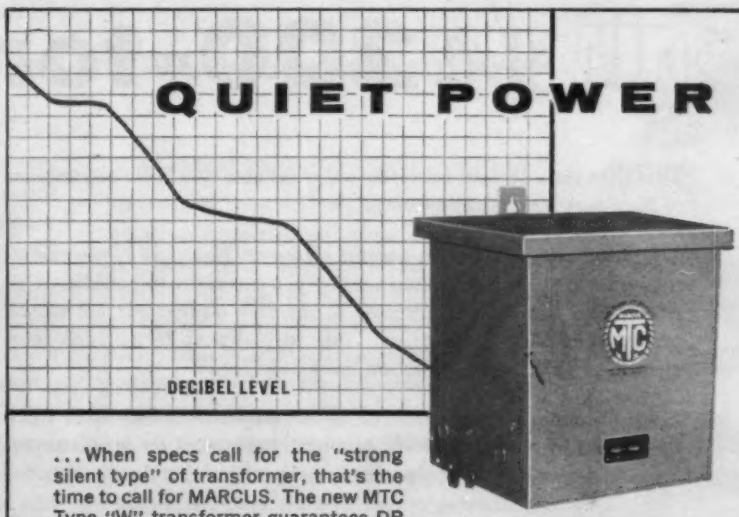

...When specs call for the "strong silent type" of transformer, that's the time to call for MARCUS. The new MTC Type "W" transformer guarantees DB LEVELS THAT ARE BELOW NEMA STANDARDS. So for those extra quiet installations, Specify MARCUS---- Proven quieter by independent laboratory test.

- LOWER SOUND LEVELS
- LOWER WEIGHTS
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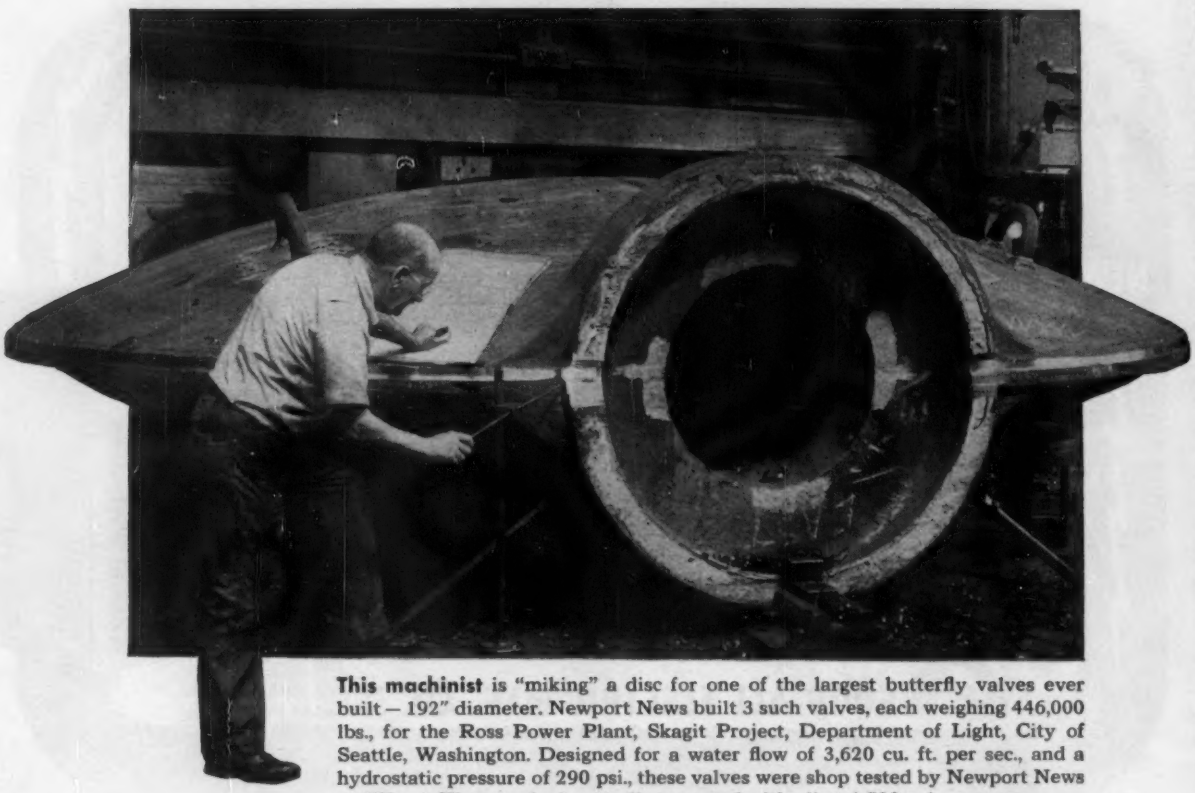
A COMPLETE LINE OF DRY-TYPE AND LIQUID-FILLED TRANSFORMERS FROM 1 THROUGH 5000 KVA.



This machinist is "miking" a disc for one of the largest butterfly valves ever built — 192" diameter. Newport News built 3 such valves, each weighing 446,000 lbs., for the Ross Power Plant, Skagit Project, Department of Light, City of Seattle, Washington. Designed for a water flow of 3,620 cu. ft. per sec., and a hydrostatic pressure of 290 psi., these valves were shop tested by Newport News at 450 psi. They are hydraulically operated with oil at 1,500 psi. pressure.

Birth of a **200-ton** Butterfly

This disc for a 16-foot butterfly valve reflects two basic advantages of Newport News fabrication...

First, it exemplifies the *careful attention* Newport News craftsmen give to every detail. And secondly, it attests to the *quality* with which Newport News produces in massive equipment for public utilities and allied industries... due to Newport News' high integration of skill and production facilities.

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Avail yourself of the engineering talent, along with the specialized production techniques and the skill of Newport News craftsmen operating vast steel fabricating shops, five huge machine shops, drop forging and die facilities along with acres of brass, iron and steel foundries.

Let us bid on equipment for your present or future projects. If you are not familiar with the way Newport News can help you, write for our illustrated booklet entitled "Water Power Equipment" ...it's yours for the asking.

NEWPORT NEWS

Shipbuilding and Dry Dock Company
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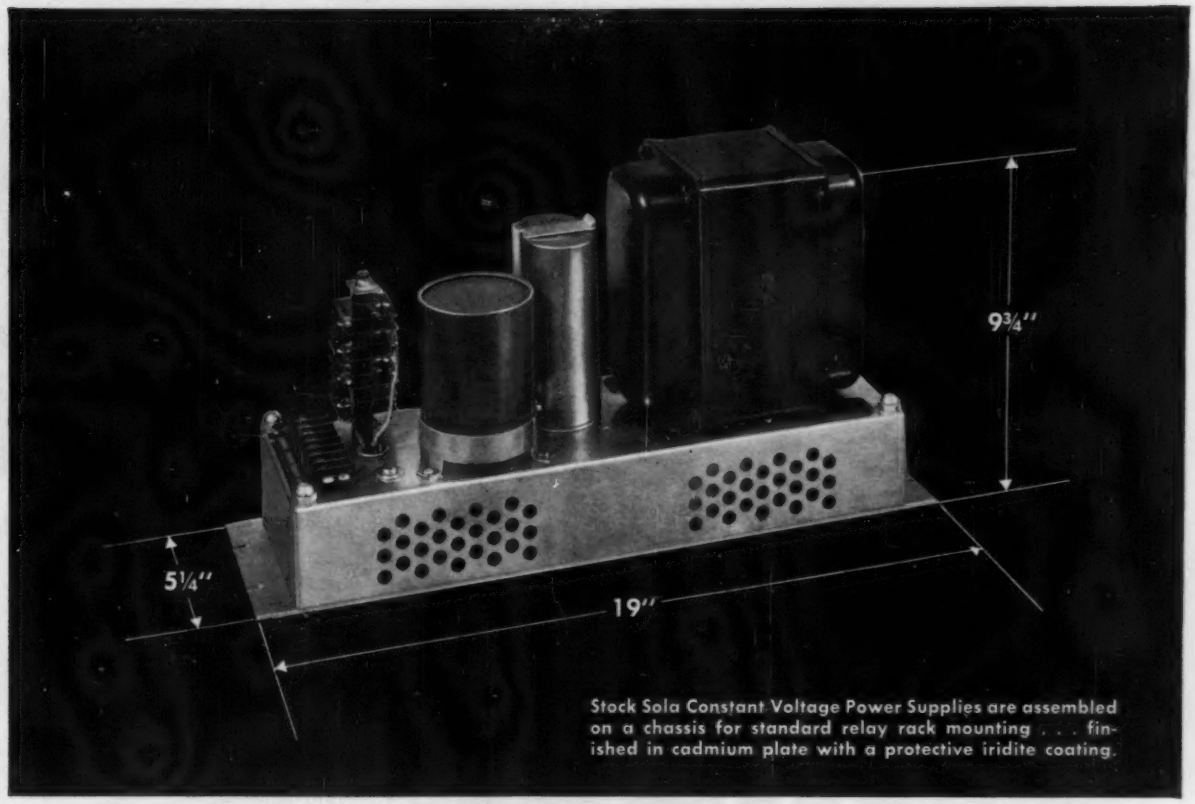


Stock Sola Constant Voltage Power Supplies are assembled on a chassis for standard relay rack mounting . . . finished in cadmium plate with a protective iridite coating.

COMPACT, regulated DC power supply

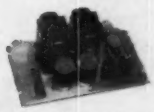
Looking for a source of regulated dc power that fits into a little space? If so, then you'll find the Sola Constant Voltage DC Power Supply is just what you want.

You'll also like to know that this space-saver is a top performer too. It's ideal for intermittent, variable or pulse loads. It delivers current in the "ampere range", regulates within ±1% with up to 10% line voltage variation, has less than 1% rms ripple, and even tolerates dead shorts. This dc power supply is 80% efficient and has an output impedance which is very low.

How's it done? Well, the answer is a unique combination of three components. A special Sola Constant Voltage Transformer is teamed up with a semiconductor rectifier and a high-capacitance filter. The Sola transformer's electrical characteristics maximize most of the advantages of the rectifier and filter, while virtually eliminating all their disadvantages. The resultant regulated dc power supply is simple, highly reliable, compact and moderately priced.

Fixed output — six ratings available from stock

Adjustable output — six ratings from stock



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You can now get greater reliability for all kinds of process and automation control in these new SCAMMIT MONITORING SYSTEMS. Components are permanent and static switching circuitry eliminates most component failure; result is years of economical and dependable alarm protection. Investigate SCAMMIT before you invest in any monitoring system.

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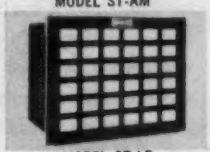

MODEL ST-LF

MODEL ST-EM

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

Trade Literature

(Continued from page 60A)

Potentiometer Data Sheet. A complete line of precision potentiometers, incremental stepping motors and synchros, and pressure switches are detailed in the Composite Sheet released by G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena, Calif. This Composite Sheet is designed to provide a quick and ready reference for the company's complete line of precision potentiometers, incremental stepping motors, and pressure switches.

Drafting Template Catalog. A complete catalog of drafting templates has recently been issued by Timely Products Company, P.O. Box 416, Basil, Ohio, originators of the Timely house plant drafting template. A copy of the catalog is available by writing to the company.

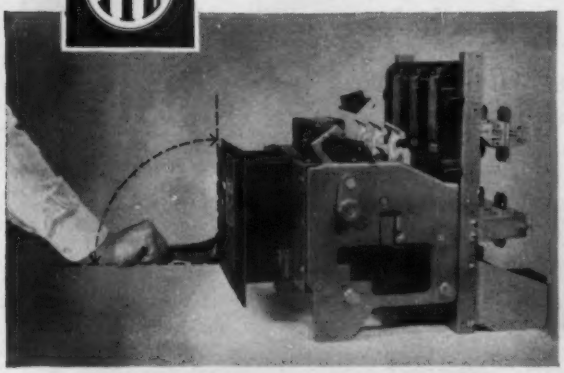
Electrician's Manual. Publication of the revised *M-110*, electrician's manual is announced. This 24-page manual gives complete information on control wiring devices. Full engineering details are given, as well as installation instructions and an explanation of the mechanical and electrical aspects of Remcon remote-control wiring devices. The manual is issued by Pyramid Instrument Corp., Remcon Division, 630 Merrick Rd., Lynbrook, N. Y.

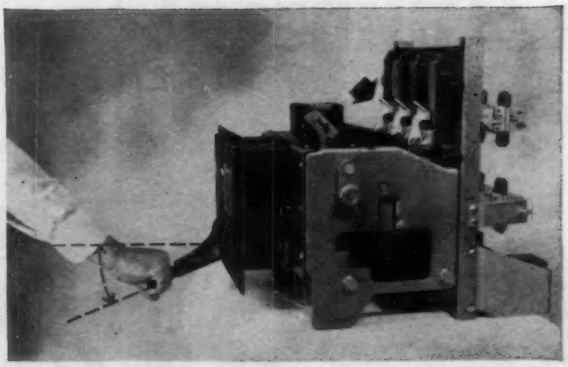
Radiagraph Machine Booklet. An 8-page booklet detailing the features of the No. *20* Radiagraph flame cutting machine is now available. The No. *20* Radiagraph is a portable, motor-driven, straight-line, track-guided machine. Limited contour, circular, and curved cutting can be accomplished by using suitable accessories which are also described in the booklet. A copy of this catalog may be obtained by writing Air Reduction Sales Company, a Division of Air Reduction Company, Inc., 150 E. 42nd St., New York 17, N. Y. Specify form *ADC 673*.

Butyl Rubber Catalyst Efficiency Bulletin. A study of the effect of moisture content on the efficiency of metallic chloride catalysts in the dimethylol phenol resin cure for Butyl rubber has been published. This study, Bulletin *100-4C*, is intended to contribute to a more complete knowledge of the various factors which affect the properties of Butyl rubber compounds cured with dimethylol phenol resins. This bulletin, *100-4C*, and previous bulletins on the resin cure (*100-4* and *100-4B*) are available upon request from Thiokol Chemical Corporation, 780 N. Clinton Ave., Trenton 7, N. J.

Computer Language Translator Brochure. A 4-page brochure describing the Model *ZA-100* computer language translator is now available from the Sales Department, Electronic Engineering Company of California, 1601 E. Chestnut, Santa Ana, Calif. The brochure describes the application, operation, and economical building block design principle of the computer language translator system which makes possible the integration of computer and data processing systems with normally incompatible formats.

K-LINE LOW VOLTAGE SWITCHGEAR





Only I-T-E has manual quick-make operation available in 225 through 1600 amp rating

Only handle moves. Contacts are static during first 90% of pulldown handle travel. In this picture, arc chutes are removed.

Too fast for the eye. When stored energy mechanism passes crossover point, energy is released to close contacts within 5 cycles.

Only I-T-E has doors closed in all positions while racking

With breaker connected. Both power and control separable contacts are engaged.

In test position. Power contacts disconnected —control contacts connected.

Completely disconnected. Both power and control contacts fully disconnected.

Quick-make, manually charged closing feature and drawout with doors closed provide maximum safety for operator and circuit breaker

You can't tease and burn the contacts of the new quick-make K-Line of circuit breakers—the closing action is fast and positive. An ingenious stored energy mechanism does the job. It stores energy in the first 90% of the pulldown handle travel, releases it in the last 10%. Not until the crossover point is reached do the contacts move. And it closes in only 5 cycles—provides uniform closure every time. *More important, it is the only manually charged stored energy circuit breaker available that will close and latch against its short-time rating.* This means greater safety for the operator, less maintenance, and longer contact life.

You don't have to open the door to move the circuit breaker to test or disconnected position. The crank which operates the simple drawout mechanism fits into the escutcheon through a lift shutter. The shutter cannot be lifted while the breaker is closed. The breaker cannot be closed while the shutter is lifted. This means more than greater safety—you can forget the dirt problem; the nuisance of open doors impeding aisle travel; the risk of circuit breaker damage from exposure, even when completely out of service.

Bulletin 6004-C gives complete information about the new and safer I-T-E K-Line of low voltage switchgear. Contact your nearest I-T-E sales office for a copy. Or write Switchgear Division, I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

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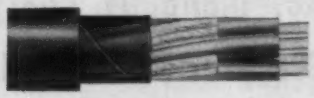
Whether your control cable installation calls for heavier insulation to give rugged dependable service on critical circuits or for routine smaller current circuits such as telemetering, pilot wire relaying, etc., . . . an Ankoseal cable will serve you best.

ANKOSEAL has just published a complete catalog on their Supervisory and Station Control Cables. Send for your copy NOW!

ANKOSEAL Type 775-P Supervisory Control Cables, 0-300 Volts.



ANKOSEAL Station Control Cables 0-600, 0-1000 and 0-300 Volts.

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624-7

WARHEAD

circa 400 A. D.

Centuries ago, the Indians of New Mexico designed and developed warheads like this one.

Today, we at Sandia Corporation do very much the same job—but we call it research and development in the ordnance phases of nuclear weapons for the Atomic Energy Commission.

The people who made these primitive warheads also applied many of the same skills and techniques to produce implements of peace—grinding stones, knives, needles, and quite a few others.

Here again, we at Sandia follow a similar pattern. In the pursuit of our main task, we study many things in widely-varied fields ranging from nuclear phenomena to numbers theory, from meteorology to metal-working. We learn basic scientific facts and advanced techniques that have important applications far removed from nuclear weapons.

We probe new frontiers of science and engineering. We meet and solve challenging problems in many areas of advanced technology. These are activities which require the services of outstanding engineers and scientists in many fields in our work to maintain our nation's defensive strength.

We have such men—both at Sandia in Albuquerque and at our branch laboratory in Livermore, California. But we need more—at the highest academic and experience levels.

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— 48% nickel alloys characterized by high permeability at low and moderate inductions and low coercive force. 48 Orthonik also offers a square hysteresis loop. Manual offers hitherto unavailable design data on these 14- to ¼-mil thick materials.

Write for a free copy of any of these design manuals that can help you use the advantages of Armco Electrical Steels in your products. Armco Steel Corporation, 2838 Curtis Street, Middletown, Ohio.

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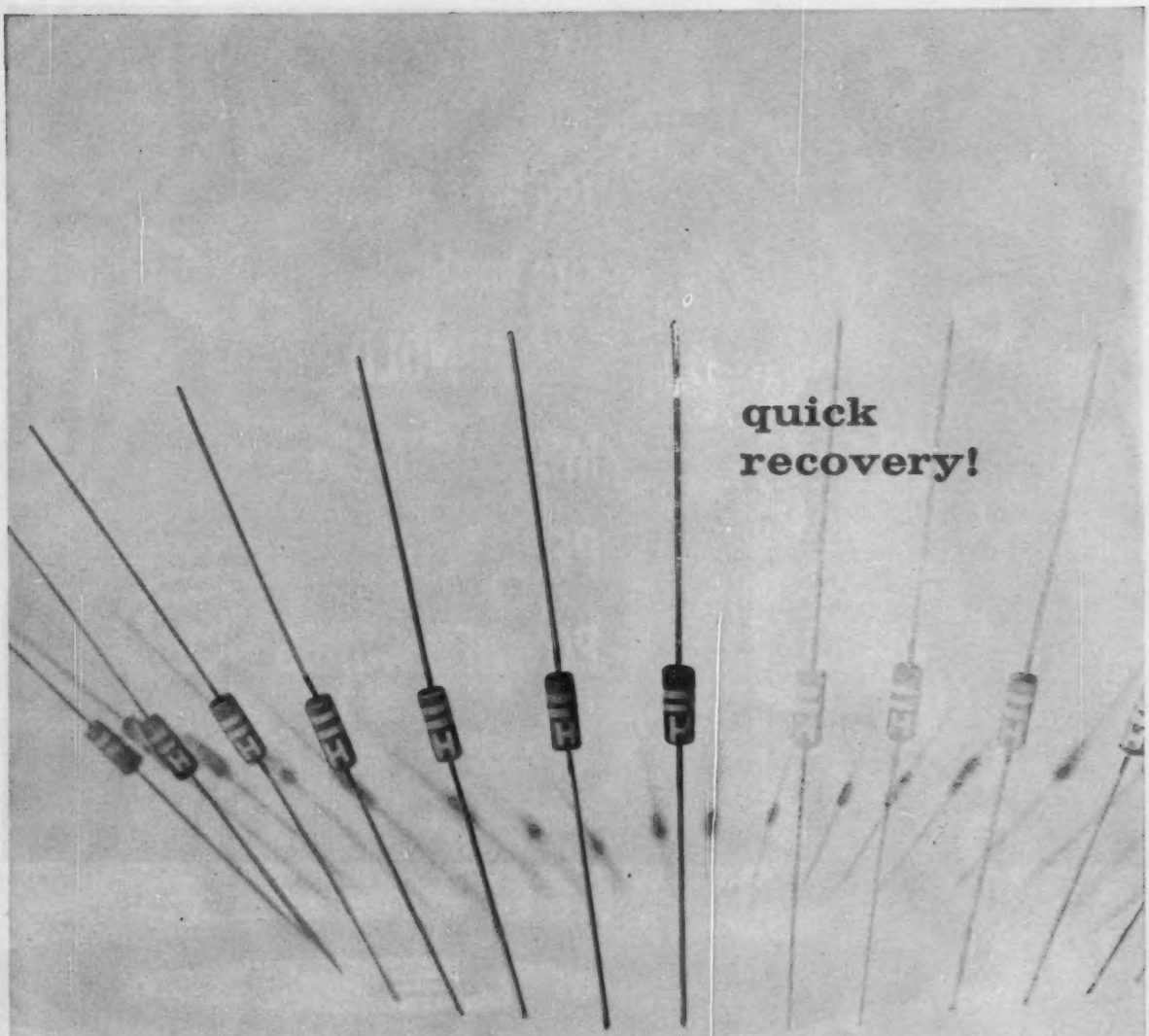

Reliable Hughes Silicon Junction Diodes

With recovery to 400 K ohms (minimum) in 1 microsecond... Hughes high-speed silicon diodes reliably meet the quick recovery requirements of most germanium types, and in addition, stand up under high voltages at high temperatures. In fact, the breakdown voltages increase with temperature... thereby providing maximum protection when temperatures reach unexpected levels. With this order of reliability, Hughes quick recovery silicon diodes assure dependability under the most severe operating temperatures.

Typical performance levels:

Breakdown voltages at current of 0.1 mA from 30-200 volts.

Ambient operating temp. —80°C to +150°C

Reverse current—as low as 1 μA at —175 volts and 25°C

—as low as 30μA at —175 volts and 100°C

Special high conductance types in the quick recovery series are available in all voltage classes. No matter what your problem, chances are that there is a Hughes diode to meet your need. Write today for a complete data sheet on the Hughes quick recovery silicon diode —or any other Hughes semiconductor device.

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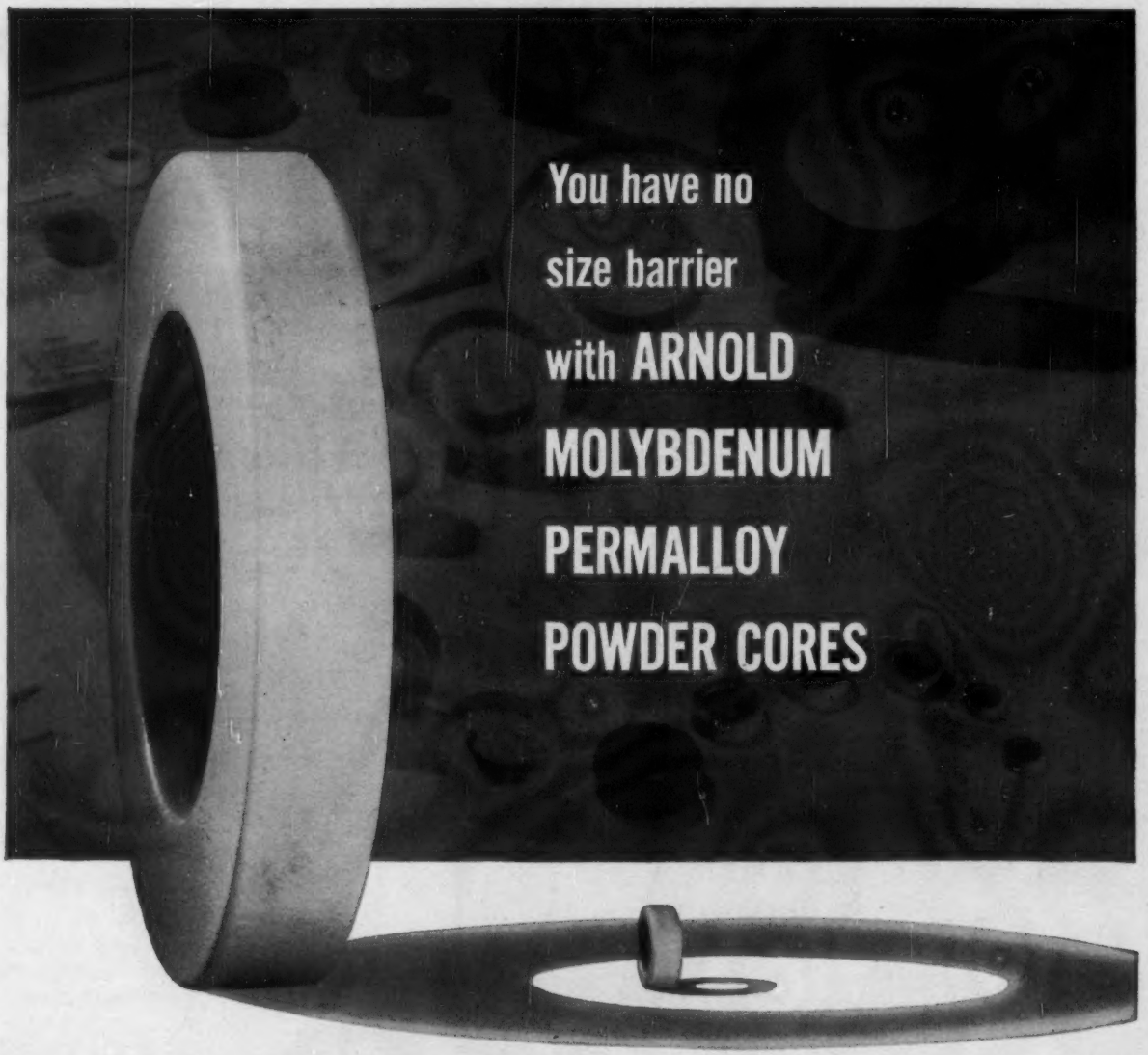

Starting with the smallest up to the largest, Arnold leads the way in offering you a full range of Molybdenum Permalloy Powder cores for greater design flexibility . . . from 0.500" O.D. to 5.218" O.D.

As long ago as 1953 Arnold pioneered and developed for production use the small "Cheerio" core illustrated above. Today, hundreds of thousands of Arnold "Cheerio" cores are filling the requirement for miniaturization in circuit design in industrial and military applications. And even smaller sizes have been developed by the Arnold Engineering Company and are available.

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WSW 6061 A

For more information write for Bulletin PC-104B

Lists complete line of Mo-Permalloy Powder cores . . . available in 23 sizes from 0.500" O.D. to 5.218" O.D. Furnished also with various types of temperature stability from Type "A" unstabilized to Type "W" stabilized over the temperature range of −65° F to +185° F.

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660,000 KVA IN A 3-PHASE BANK

220,000 kVa Brown Boveri single-phase autotransformer, BIL 1450 kV, 400/230/30 kV with TCUL regulation ± 18% on 230 kV side.

world's largest power transformer with the smallest weight per kVA

EACH single-phase, Schnabel-car-designed-unit weighing 441,000 lbs. (including oil) was shipped completely assembled with coolers except for the high voltage bushings which were removed for transport. Two days after arrival of the transformers they were ready for energization.

In successful operation since Oct. 1957, these transformers are an important addition to Brown Boveri's vast experience in designing and manufacturing transmission equipment for 400 kV and higher system voltages of the future.

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Please write to: Mr. D. K. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

Westinghouse Awarded $22 Million Navy Contract

The company's Friendship Airport plant will produce shipboard radio transmitters and radar equipment which it designed.

The radar particularly is considered a revolutionary breakthrough in electronics, permitting results identical to that achieved by conventional radar with 30 times the power.

R. E. KIRBY, manager of the electronic division, said there are actually three contracts involved.

One worth more than $8 million is for production of the advanced air-search radar. It is to be used on carriers, cruisers and other ships.

The second contract is for $1 million worth of conventional design radar.

The largest contract, more than $12 million, is for production of medium and high frequency communications transmitters. These would be used on surface ships and submarines.

"The new radar equipment," Kirby said, "employs a revolutionary electronic circuit technique considered a technological breakthrough in the evolution of shipboard air-search radar." It was designed and tested here.

The transmitter is the product of Westinghouse research begun in 1951.

This Navy contract is the result of another major technological breakthrough by our outstanding team of engineers at Westinghouse–Baltimore. An exciting opportunity exists for qualified engineers to join this team. You will be a part of our wide range new development program which will result in a continuing pattern of major breakthroughs in the future.

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Microwave Components
Network Synthesis

TO APPLY: Send a resume of your education and experience to Dr. J. A. Medwin, Dept. 824, Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.

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- Antenna design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstron, traveling wave tube and backward wave oscillator
- Display and storage devices

CIVILIAN
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• VHF & UHF Receiver • Transmitter design & development • Power supply • Systems Engineering • Selective Signaling • Transistor Applications • Crystal Engineering • Sales Engineers

PORTABLE COMMUNICATIONS
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We need engineers to do research and development based on an entirely new electronics test equipment philosophy. Briefly, the job involves design of test equipment and analysis of electronics designs submitted by vendors and subcontractors. This is one phase of our work on advanced weapon systems B-70 and F-108.

A BSEE, plus experience, can qualify you.

For more information please write to: Mr. D. K. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 15, Calif.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

DON'T GET ME WRONG...I STILL DON'T LIKE STORMS

"But they don't seem to hit us so hard any more. Not since polyethylene coated wire came along."

The lineman's boss also gives polyethylene credit for reducing outages during storms. This tough plastic forms a continuous shield that resists moisture, weathering and aging. It protects the conductor from contact with wind-whipped branches and wires, prevents short circuiting by chance electrical contacts.

Protection is long-lasting. Early installations have shown no deterioration after 11 years exposure to all sorts of weather. And accelerated aging tests point to an expected life as great as 40 years.

In winter, polyethylene coated wire stands up better than other types because it is lighter, has a smaller diameter. It offers less resistance to wind and ice . . . supports a greater weight of ice without breaking.

Easier Installation, too . . .

Polyethylene is easy to handle because it's clean . . . self-lubricating . . . readily stripped. Yet it adheres well, doesn't ruffle when pulled.

Here are some of the applications where polyethylene is giving outstanding service:

- Line wire covering
- Communication cable insulation and sheaths
- Power cable dielectric
- Tree wire covering
- GTO (Neon Sign) Cable
- WD-1 Infantry Field Wire
- Control cable insulation and jacket
- Corrosion protection for metal sheaths
- TV Lead Wire

But all polyethylenes aren't the same. Ask your supplier about the superior weather and stress-crack resistance of coatings made with PETROTHENE® polyethylene resins. You pay no more for PETROTHENE quality.

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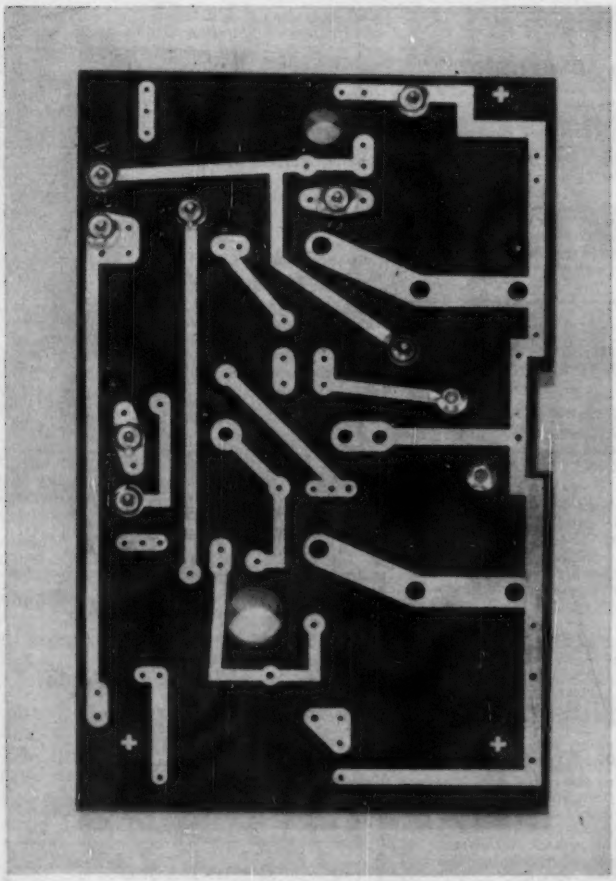

How CDF Di-Clad† can solve your printed-circuit problems

The CDF line of copper-clad laminates in all grades is now known by a new name—Di-Clad. Di-Clad grades meet the varying needs of design, production, and operation of electronic equipment. Grades other than those described are also available.

Di-Clad 28E. For high mechanical strength, low moisture-absorption, and good insulation resistance, CDF Di-Clad laminates of epoxy resin laminated with glass fabric offer the designer a strong, reliable combination.

Di-Clad 112T. A Teflon* glass-fabric laminate offering the best dielectric properties over a wide temperature and frequency range.

Send us your requirements and let our engineers help you select the right grade for your application.

†Trademark of Continental-Diamond Fibre Corporation
*Du Pont trademark for its tetrafluoroethylene resin.

Di-Clad 2350. An economy paper-base phenolic grade having good tensile, flexural, compressive, and impact strength. Adequate for most non-critical printed-circuit applications. Can be cold punched and sheared up to 5/64 of an inch in thickness.

CONTINENTAL-DIAMOND FIBRE
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TYPICAL Di-Clad PROPERTY VALUES

	Di-Clad 2350	Di-Clad 26 (NEMA XXXP)	Di-Clad 28 (NEMA XXXP)	Di-Clad 28E (NEMA G-10)	Di-Clad 112T Teflon*
BOND STRENGTH—0.0014" foil (lbs. reqd. to separate 1" width of foil from laminate)	6 to 10	6 to 10	6 to 10	8 to 12	4 to 8
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (Deg. C.)	120	120	120	150	200
DIELECTRIC STRENGTH (Maximum voltage per mil for 1/16" thickness)	800	900	850	650	700
INSULATION RESISTANCE (Megohms) 96 hrs. at 35°C. & 90% RH (ASTM D257, Fig. 3)	500	150,000	600,000	100,000	75,000
DIELECTRIC CONSTANT 10^6 Cycles	4.5	4.0	3.6	4.9	2.6
DISSIPATION FACTOR 10^6 Cycles	0.040	0.026	0.027	0.019	0.0015
ARC-RESISTANCE (Seconds)	5	10	10	130	180
TENSILE STRENGTH (psi.)	18,000	16,000	12,000	48,000	23,000
FLEXURAL STRENGTH (psi.)	27,000	21,000	18,000	70,000	13,000
IZOD IMPACT STRENGTH edgewise (ft. lbs. per inch of notch)	0.80	0.45	0.42	12.0	6.0
COMPRESSIVE STRENGTH flatwise (psi.)	32,000	28,000	25,000	62,000	20,000
BASE MATERIAL OF LAMINATE	Paper	Paper	Paper	Medium-weave, medium-weight glass cloth	Fine-weave, medium-weight glass cloth
COLOR OF UNCLAD LAMINATE	Natural	Natural greenish	Natural	Natural	Natural

All these standard grades are available with 0.0014" and 0.0028" or thicker electrolytic or rolled copper foil on one or both surfaces. Other metal foils and other resin-and-base combinations can be supplied on special order.

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ELECTRICAL ENGINEER, physicist, chemist for fundamental project on effects of radiation on dielectrics. Capacitor experience desirable. Send resume to: Radiation Research Corporation, 1114 First Avenue, New York, New York.

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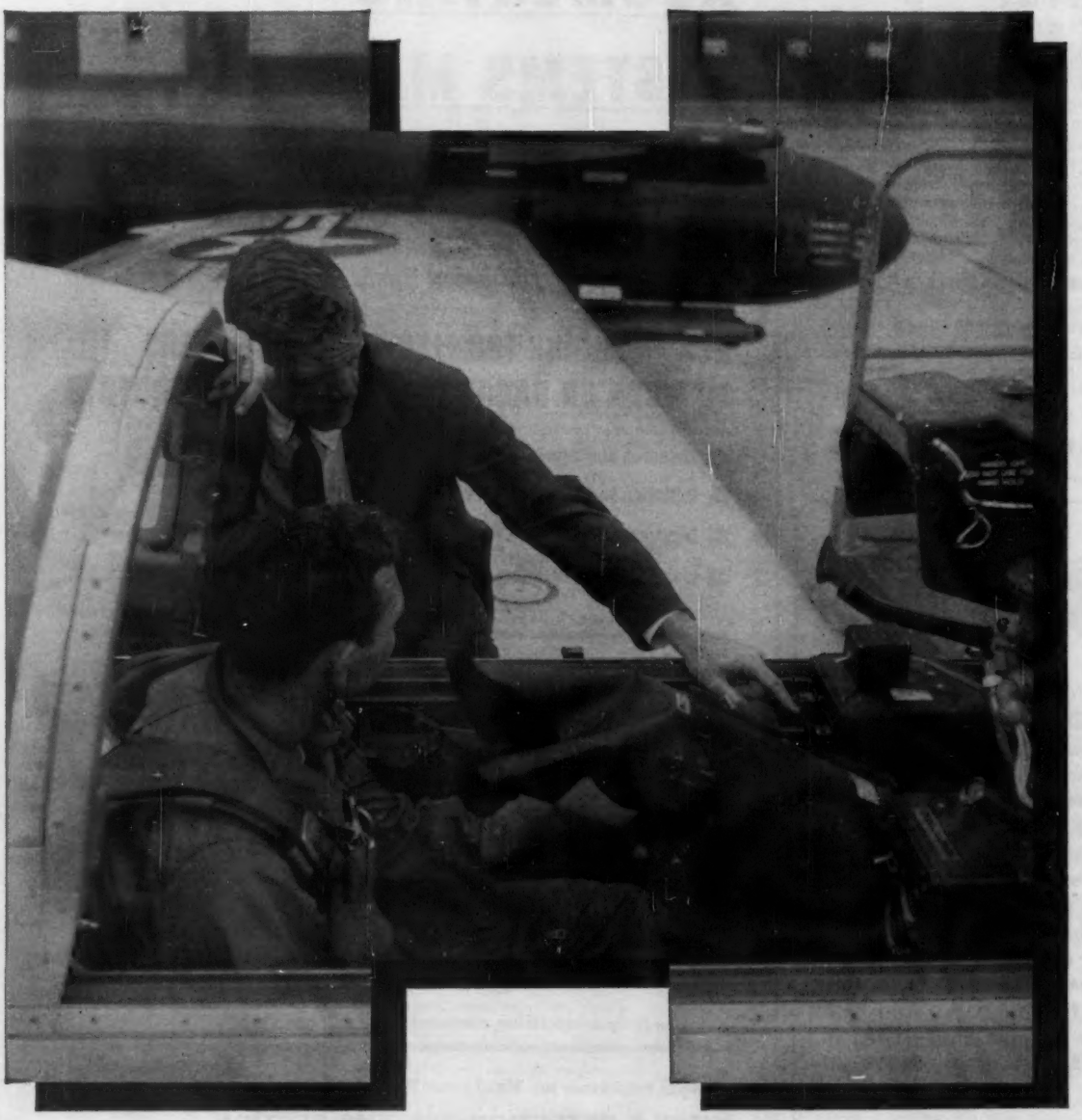

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He takes Laboratory designed electronic systems and evaluates them where they actually prove themselves. He makes this equipment produce everything that was designed into it. His title: Hughes Field Engineer.

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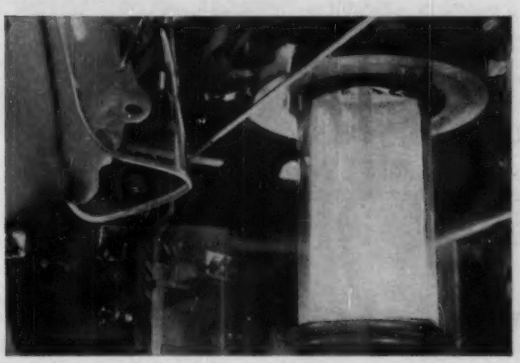

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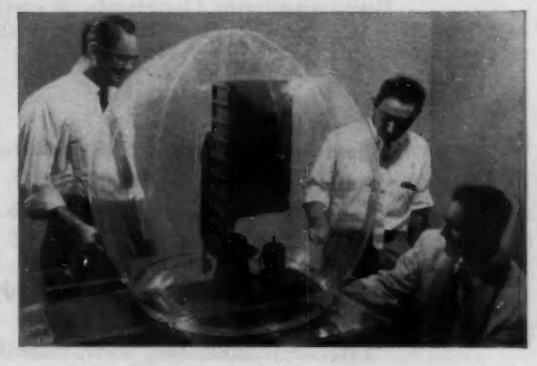

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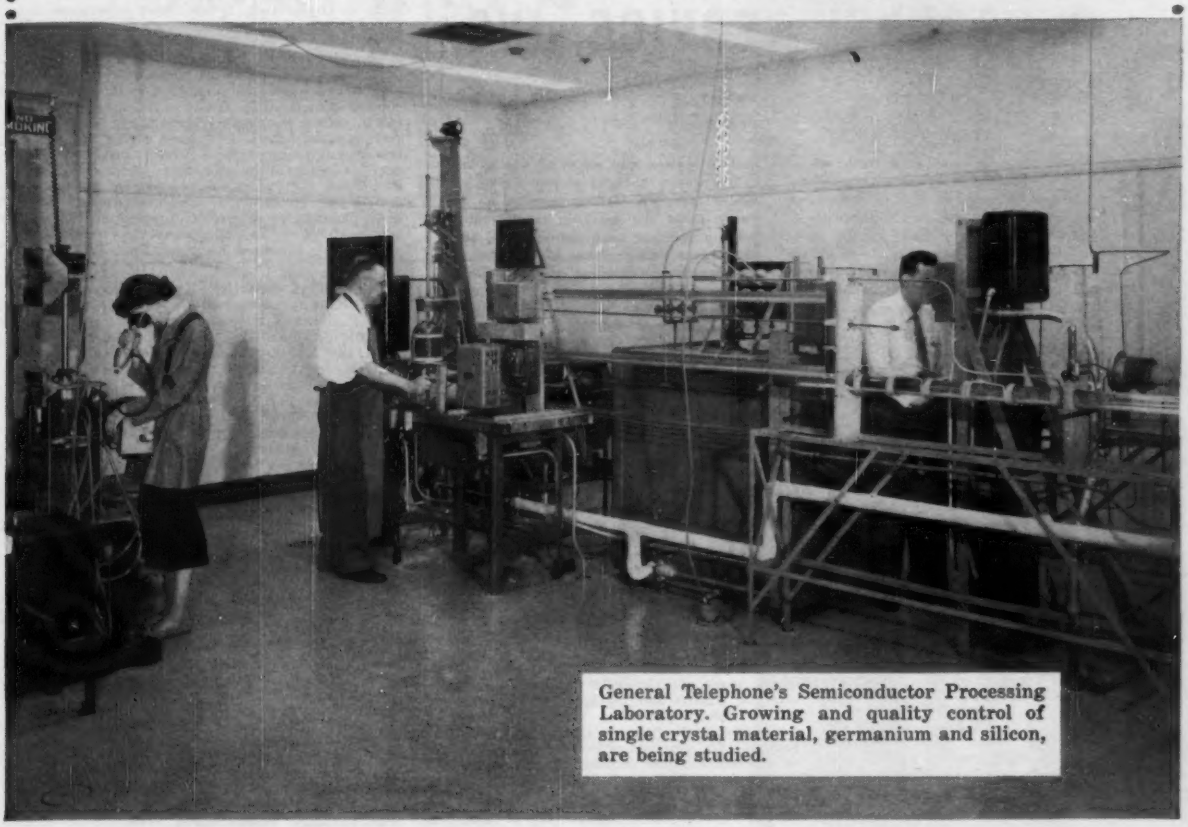
The GENERAL Idea on Engineering Careers



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ENGINEERS. (a) Contract Administrators, B.S.E.E. or B.S.M.E. preferred, but a business major would be acceptable. Three years' experience in actual military contract administration. Experience in development or production of electro-mechanical inertial instrumentation including a knowledge of mechanics, electronics or physics. Duties will include administrative responsibilities for major product programs involving planning, schedules and quotations. Salary, from $7920 a year. (b) B.S.M.E. or E.E., or M.S.M.E. or Design and development of electromechanical instruments such as gyros, accelerometers, synchros and related instruments. Will plan and direct activities of a complete project of complicated electronic, mechanical, electromechanical equipment. Salary, from $9000 a year. Location, Massachusetts. W6435.

ELECTRICAL OR MECHANICAL ENGINEER, recent graduate, who is interested in a career in Latin America with an electric light and power company. One-year training, period prior to going to Latin America. Should have potential for eventual advancement to management position. Starting salary commensurate with qualifications. F6449.

DESIGN ENGINEERS, project or senior level. (a) Transistor Circuit Design Engineer, with a minimum of three to four years' transistor circuit design experience. Area of interest, RF 20 to 100 mc, audio and FM. Will work on design and development project involving FM signal generator and related equipment. (b) Vacuum Tube Circuit Design Engineer with a minimum of five years' vacuum tube circuit design experience. Area of interest, RF around 400 mc, AM and FM modulation, carrier frequency comparison and AFC with external reference, low power output. Will work on design and development projects involving special measurements instrumentation. Salaries: project level, $10,000-$12,000 a year; senior level, $8000-$10,000 a year; generous fringe benefits. Location, Westchester County, New York. W6452.

SENIOR COMMUNICATIONS ENGINEER, electrical graduate, with field engineering, operating and managerial experience in telephone and radio fields. Salary, $12,000-$15,000 a year. Headquarters, New York, N. Y. W6454.

ELECTRICAL ENGINEERS for a mining operation. (a) One graduate electrical engineer with from five to ten years' experience in power distribution. Experience in Latin America desired. (b) One recent graduate electrical engineer. Salaries open. Location, Caribbean area. F6461.

(Continued on page 86A)

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Fuel fabrication: Metallurgical and mechanical engineers for fabrication development of materials and elements.

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Compact reactors and power conversion: Nuclear, mechanical engineers. Design, installation, checkout, operation, and environment tests for satellite auxiliary power plants.
Instrumentation and control: EE's and applied physicists. Design, develop, analyze, and test advanced automatic power plant control systems and components.
Mechanical components: ME required. Develop coolant, other equipment for power reactors. Problems in thermodynamics, stress, heat transfer, and fluid dynamics. Metallurgist for research on reactor structural materials. Desire alloy development and solid state diffusion experience.

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Responsible positions. Degree essential. Experience as required.
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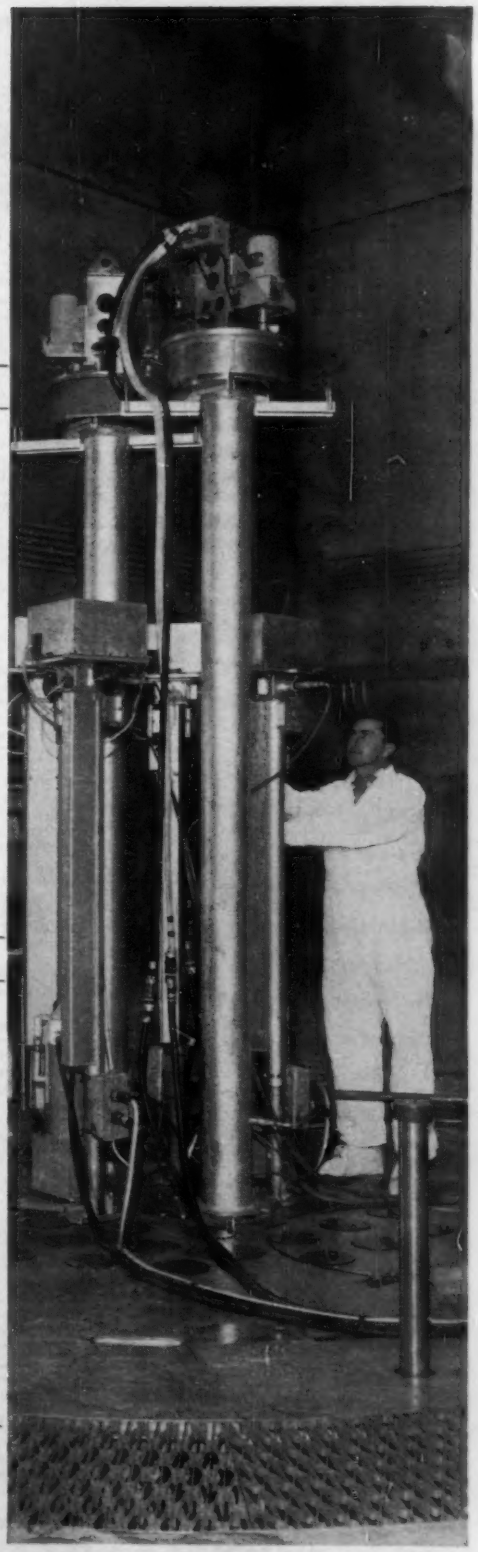

SRE Reactor Control Element Actuators. Sodium Graphite Reactor (SRE) uses eight control actuators. Four function as safety rods, two as shim rods, and two serve as shim regulating rods.

FEEDBACK CONTROL SYSTEMS CONFERENCE

The second Feedback Control Systems Conference was held April 21-23, 1954 at Atlantic City, N. J. The papers, as prepared by their respective authors are included in publication S-63. The technical papers and scheduled demonstrations covered the following fields and subjects:

Industrial regulators
Tracer machine tools
Process control
Nucleonics
Aircraft engines
Flight path control
Fire control
Platform stabilization
Flight simulators
Computers
Test equipment
Magnetic Amplifiers
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Gears and dampers

The preceding list indicates a wide range of applications of feedback control as well as the diversity of components.

This 158-page publication, S-63, is available at the price of $3.50 to members and non-members from the Order Department

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

Personnel Service, Inc.

(Continued from page 84A)

MANAGER, electrical graduate, with broad experience in electrical fields and at least ten years' supervisory office experience in preparation of specifications, reports, standards and administrative duties covering research, engineering and application of electrical equipment. Salary, $11,000-$15,000 a year. Location, New York, N. Y. W6465.

SENIOR SALES ENGINEER, graduate electrical, with sales experience covering industrial electronic or electro-chemical controls to government agencies, preferably in environmental and low temperature fields. Salary, $12,000-$14,000 a year. Location, eastern Pennsylvania. W6471.

ELECTRIC MOTOR DESIGNER, graduate electrical, with at least seven to ten years' experience in polyphase induction motor design work in the industrial sizes 200 hp and smaller. Will do electrical design of general purpose machines as well as considerable design work on special purpose machines such as multi-speeds, wound rotor, intermittent ratings, high torque, high slip machines, etc. considerable development work in the polyphase line. Salary, $8400-$9300 a year. Location, Ohio. W6472.

PROJECT ENGINEERS, registered engineers, proficient in client contact; able to handle preliminary negotiations and carry job through layout, design, cost estimates, reports and supervision of construction. (a) Electrical with general and building experience; power and light distribution; some power generation; industrial controls. (b) Mechanical with wide experience in heating, ventilating, air conditioning, piping of all kinds, equipment selection; liquid, solid and gas material handling; commercial and industrial work. Apply by letter giving full details including salary requirements. Headquarters, New England. W6481.

SENIOR ELECTRICAL DEVELOPMENT ENGINEER, B.S.E.E. required, M.S. preferred; to work on development and design of analytical instrumentation involving principles of pulse and digital circuitry and extremely high voltage power supplies. Minimum of five years' instrument design experience with emphasis on pulse circuitry, regulated D.C. power supplies, etc. Salary, to $11,000 a year. Company offers a wide range of employee benefits; may negotiate placement fee. Location, suburban New York. W6487(a).

SALES ENGINEERS, Instrument Sales Division, graduate electrical or mechanical, preferably married, with three years' direct engineering experience closely related to airborne equipment design, telemetering or instrumentation design; two years' of directly related sales experience. Six-month training program on West Coast. Salary, from $9000-$10,200 a year to start depending upon experience, fringe benefits; expenses. Company may negotiate placement fee. Territory, New Jersey, New York Metropolitan area and possibly Long Island. W6493.

COMPUTER ENGINEERS, junior and senior level. (a) Electrical to assist in a computer program in initial phases of development. Assignments will be in fields of logical design, electronic and electro-mechanical digital computer equipment design, systems requirement and the design of logical circuits, memory and input-output buffers, reliable transistor and magnetic core circuitry for digital data systems. (b) Electro-mechanical for development work on input-output devices for electrical computers. Work will include development of high speed paper and card processing devices and high speed printers as well as associated electronic controls. Strong mechanical experience in the design of small intricate mechanisms needed; experience in electronic controls with some knowledge of mechanical design helpful. Salaries open depending upon experience. Company pays placement fees. Location, Connecticut. W6496.

TRANSDUCER SALES ENGINEER for leading instrument manufacturer; graduate mechanical, electrical, or aeronautical engineer, with at least four years' of pertinent experience in flight test, project engineering or associated fields. Should have experience and ability to apply and sell transducers for pressure, acceleration, temperature and gyros. Top salary plus expenses, plus incentive. Headquarters, New York City. W6500.

INSTRUCTORS OR ASSISTANT PROFESSORS to teach courses in electrical engineering, mechanical engineering, civil engineering, mathematics or physics. Some teaching experience desired. Salaries open. Location, New England. W6505.

SALES ENGINEER—Steam Plant Products, mechanical or electrical, with a minimum of five years' experience selling direct, preferably boiler plant equipment and supplies to industry (chemical, food or any plant with boiler plant). Sell steam plant controls, meters, valves, glasses, traps for established manufacturers agent. Need car. Compensation on draw, salary or percentage basis, potential excellent. Location, San Francisco East Bay and Central California. S3719R.

JUNIOR MECHANICAL AND ELECTRICAL ENGINEER, Public Works, graduate mechanical or electrical engineer, knowledge of principles mechanical and electrical engineer, methods, materials, as applied to design, construction, inspection and testing, able to do drafting for mechanical and electrical installations; for all phases of mechanical and electrical engineering connected with port, airport and industrial operations. Salary, $6000-$7900 a year. Location, San Francisco East Bay. SG3719.

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Be sure to address all Personnel Service box numbers to Box _____

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ELECTRICAL DESIGN ENGINEER, preferably B.S., with several years' experience on design and development for manufacturer of commercial electrical heating appliances. Should have creative ability. Salary, $7200-$9000 a year. Location, San Francisco. S3727R.

SYSTEMS ENGINEER, electronics, electrical engineer or equivalent, broad background in communications and radar on general engineering and installation; able to design circuits, computers, enclosures, prepare proposals and have knowledge of military and commercial devices, including ultra high frequency, carrier, communications, centers. For consultant and development laboratory. Salaries: $5400-$6600 for no degree; $6600-$7800 for experience and degree. Location, San Francisco. S3729R.

RESEARCH AND DEVELOPMENT ENGINEER, Production-Missiles Systems; graduate engineer, science, physics, chemical, well qualified by academic and working experience to fit into research and development laboratory or into project organizational divisions on military contract work—controls, guidance, propulsion, data reduction; seeking high level candidates for established missiles and satellite investigations, development, manufacturer and test. Salary commensurate with capabilities. Location, San Francisco. S3732.

DESIGNER, Industrial electrical, electrical engineering graduate, preferably registered or qualified for registration, several years' experience in consultant's office, on industrial process distribution and circuits (switchgear, substation) for process type plants; able to make short cut analysis, development plans, make layouts and do board work for consultant (heavy and larger commercial installations). Salary, $7800-$9000 a year. Location, San Francisco. S3782.

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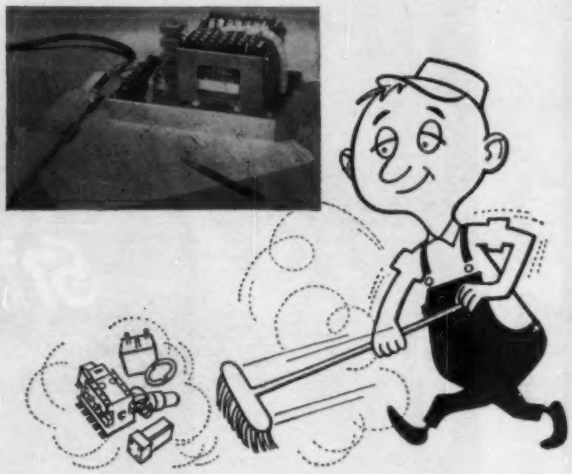

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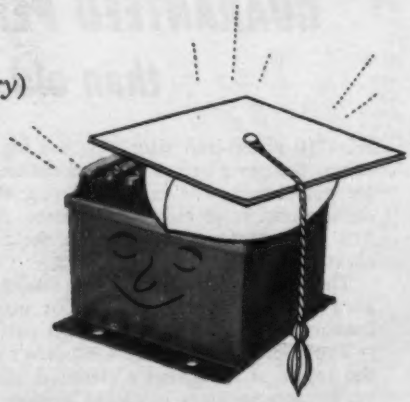

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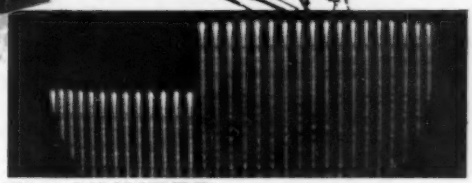

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. . . meets MIL-E-4158A requirements. Control circuit is on one panel; Variac, buck-boost transformer and servo-motor are on another.

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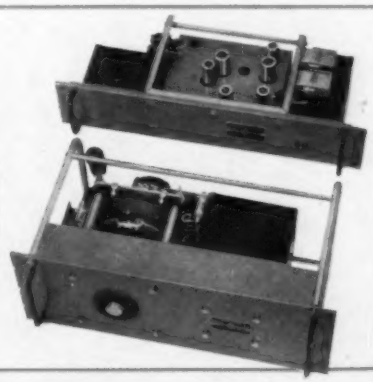

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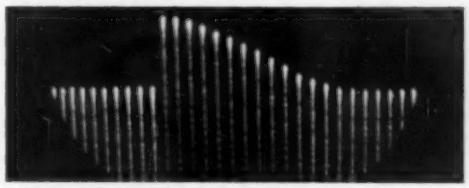

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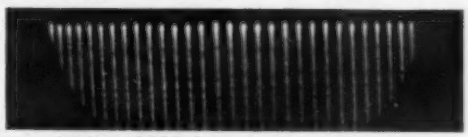

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TOP TUBE PERFORMANCE

RCA Announces a new, comprehensive Line of Mobile Communications Tubes for 6-Cell Storage-Battery Operation...in automotive, aircraft, marine, and industrial equipment

AGAIN, RCA IS FIRST—with a line of mobile communications tubes that will insure reliable service in mobile equipment operating with a terminal supply voltage ranging all the way from 12 to 15 volts (they will take momentary excursions from 11 to 16 volts)!

Here is a line of tubes that takes the extra plate and screen dissipation at "cruising" speeds—and yet delivers satisfactory performance at engine "idle". Specially designed and controlled 13.5-volt heaters safely withstand the charge and discharge voltages of 12-volt electrical systems. In addition they are designed to withstand intermittent heater-cycling tests of 2000 cycles minimum, at high heater voltage. Each tube type is subjected during manufacture to rigid tests for heater-cathode leakage, interelectrode leakage, elevated-heater-voltage life performance, and intermittent shorts.

There is a new RCA mobile type for every tube function in your transceiver design. Study the block diagram on the right—check the list for the types you need.

NOTICE TO DESIGNERS OF MOBILE RADIO EQUIPMENT!

Your RCA Field Representative can discuss applications of the new RCA Mobile line immediately. Call him at the RCA Field Office nearest you. For technical data on these tubes, write RCA Commercial Engineering, Section J-16-Q Harrison, N.J.

RCA-7054—Power Pentode. For class C rf power amplifier, oscillator, frequency multiplier, up to 40 Mc. Also for modulator, af power amplifier.

RCA-7055—Twin Diode. For low-current rectifier, detector, speech-clipper.

RCA-7056—Sharp-Cutoff Pentode. For if amplifier and rf amplifier up to 45 Mc.

RCA-7057—Medium-Mμ Twin Triode. For rf amplifier in cascode-type circuits up to 200 Mc.

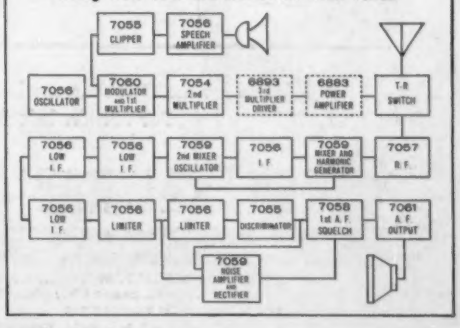
RCA-7058—High-Mμ Twin Triode. For phase-inverter, resistance-coupled amplifier, low-frequency oscillator.

RCA-7059—Medium-Mμ Triode—Sharp-Cutoff Pentode. For oscillator-mixer at if frequencies up to 40 Mc. Triode unit also useful for vhf oscillator, and—connected as diode—for high-perveance rectifier in noise-squelch circuits.

RCA-7060—Medium-Mμ Triode—Power Pentode. Triode useful for reactance modulator; pentode as Class C rf power amplifier, frequency multiplier, up to 40 Mc.

RCA-7061—Beam Power Tube. For af power amplifier.

Tube line-up for typical Mobile Transceiver... using RCA 13.5-volt Heater-Cathode Tubes



RADIO CORPORATION OF AMERICA
Electron Tube Division **Harrison, N. J.**